U.S. DEPARTMENT OF COMMERCE

PB80-167257

# Freshwater Findings, 1976-1978
## Research Publications of the Environmental Research Laboratory, Duluth, Minnesota

(U.S.) Environmental Research Lab.
Duluth, MN

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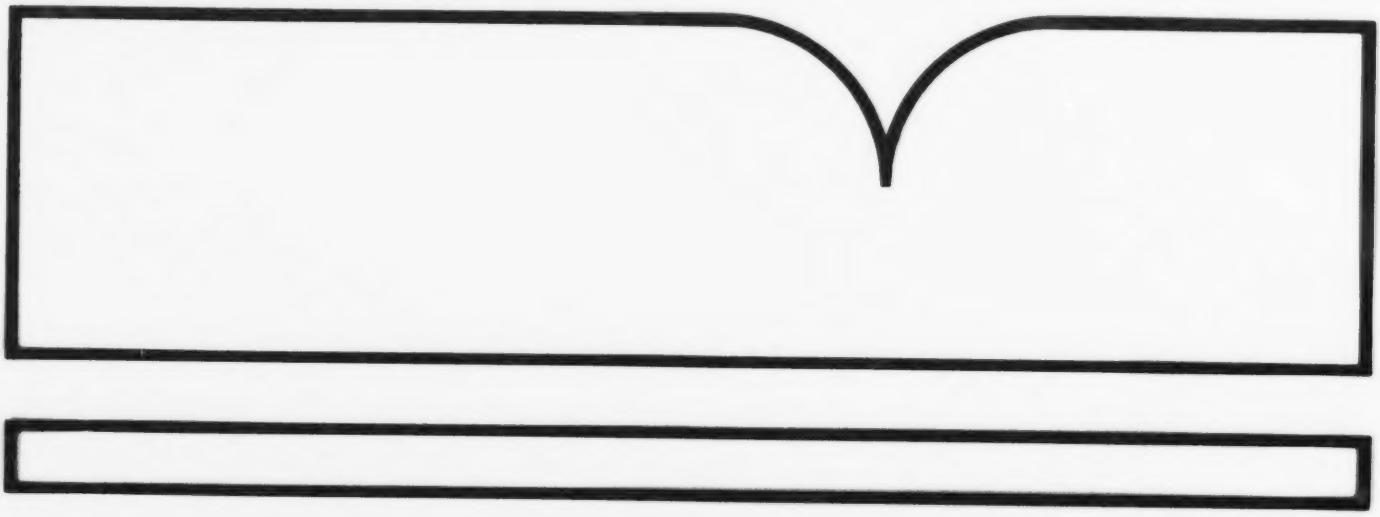

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# EPA Freshwater Findings 1976—1978

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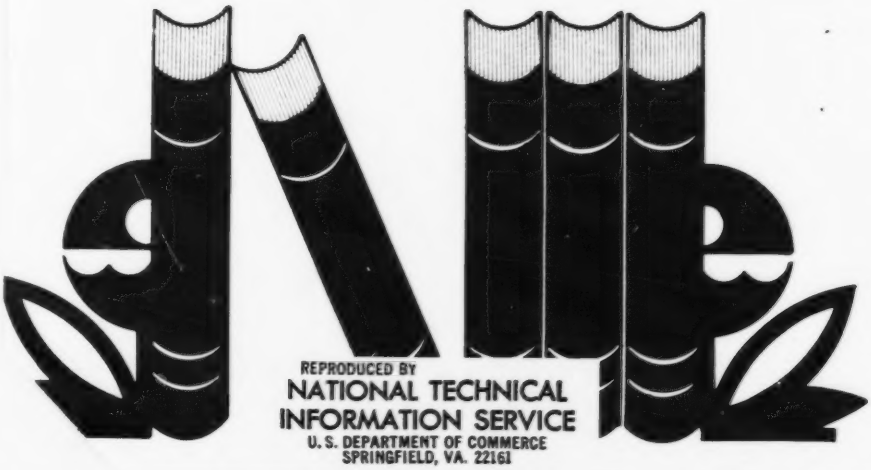

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16. ABSTRACT

This bibliography, inclusive from 1976 through 1978 lists all publications authored by personnel of the Environmental Research Laboratory-Duluth. Not only does the bibliography list all scientific materials (journal articles, research reports, and other) published by the laboratory staff, but also those project reports prepared by universities, industries, and other government researchers conducting studies under the funding and direction of this laboratory.

The publications are grouped in two sections---reports published by the EPA's (and precursor agencies') research series and journal articles from the scientific literature. Each category is subdivided by year and are annotated. Within each year, publications are listed alphabetically by the senior author's last name, and sources of reprints are identified. Introductory materials include a list of standard abbreviations for scientific journals cited and pertinent components of the EPA and the laboratory. The bibliography concludes with an author and key word index for all entries.

17. KEY WORDS AND DOCUMENT ANALYSIS

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# FRESHWATER FINDINGS, 1976 - 1978

Research Publications of the
Environmental Research Laboratory
Duluth, Minnesota

compiled by

Chris Russom
Environmental Research Laboratory
6201 Congdon Boulevard
Duluth, Minnesota 55804

ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
DULUTH, MINNESOTA 55804

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# FOREWORD

Our nation's freshwaters are vital for all animals and plants, yet our diverse uses of water---for recreation, food, energy, transportation, and industry---physically and chemically alter lakes, rivers, and streams. Such alterations threaten terrestrial organisms, as well as those living in water. The Environmental Research Laboratory in Duluth, Minnesota develops methods, conducts laboratory and field studies, and extrapolates research findings

--to determine how physical and chemical pollution affects aquatic life

--to assess the effects of ecosystems on pollutants

--to predict effects of pollutants on large lakes through use of models

--to measure bioaccumulation of pollutants in aquatic organisms that are consumed by other animals, including man

Recognizing that the research findings of the Environmental Research Laboratory-Duluth comprise a significant contribution to freshwater data, this volume provides a compilation of the scientific publications documenting those findings for the period from 1976 through 1978. This bibliography lists all project reports prepared by universities, industries, and other government researchers conducting studies under the funding and direction of the Environmental Research Laboratory-Duluth during this time period. Furthermore, this list includes all scientific materials---journal articles, research reports, and other publications---authored by the laboratory's own staff. In combination with the earlier publication, Freshwater Findings, 1967-1976, a complete record of research output during the existence of the laboratory is provided.

J. David Yount, Ph.D.
Acting Director
Environmental Research Laboratory
Duluth, Minnesota

# PREFACE

Since 1967, staff scientists at the Environmental Research Laboratory-Duluth (ERL-D) and at our field stations have made their research results available to other scientists. By publishing in the technical literature, government reports, and other scientific materials, ERL-D researchers have shared their expertise.

Researchers in industry, universities, and other government agencies throughout the country have received funding from ERL-D to conduct freshwater studies that complement the work of the ERL-D staff. To ensure that a complete record of that work is available to the public, the Environmental Protection Agency stipulates that each project must yield a comprehensive final report published either in its research report series or in the open literature. Projects completed by ERL-D staff may also be reported in that series.

These findings by ERL-D staff and the extramural scientists funded by the laboratory comprise a significant portion of the data that regulatory agencies use to set criteria to protect aquatic life---criteria that ultimately protect humans and other animals that drink or consume food from fresh water.

To ensure ready availability of this information to others who could use it to maintain and improve fresh water quality a bibliography entitled "Freshwater Findings, 1967-1976" was published. This publication is a continuation of that bibliography, listing publications from 1976 through 1978.

The publications are grouped in two main sections--reports published in the Environmental Protection Agency's (and precursor agencies') research series, and journal articles from the scientific literature. Each of these categories is subdivided into years, and each publication is listed alphabetically by the senior author's last name and is annotated to give more complete information. To help readers to get available copies sources of reprints are identified.

To make the publication even more usable to the reader, an author and a key word index for all entries is included.

Introductory materials include a list of standard abbreviations for the scientific journals cited in the bibliography and for sources listed after each abstract and ordering instructions.

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# LIST OF ABBREVIATIONS

## journals

| | |
|---|---|
| Anal. Chem. Acta. | Analytical Chemica Acta |
| Anal. Chem. | Analytical Chemistry |
| Ann. N.Y. Acad. Sci. | Annals of the New York Academy of Sciences |
| Arch. Environ. Contam. Toxicol. | Archives of Environmental Contamination and Toxicology |
| ASTM | American Society for Testing and Methods |
| Bull. Environ. Contam. Toxicol. | Bulletin of Environmental Contamination and Toxicology |
| Environ. Pollut. | Environmental Pollution |
| Int. Assoc. Great Lakes Res. | International Association of Great Lakes Research |
| J. Am. Water Works Assoc. | Journal of the American Water Works Association |
| J. Exp. Mar. Biol. Ecol. | Journal of Experimental Marine Biology and Ecology |
| J. Fish Biology | Journal of Fish Biology |
| J. Fish. Res. Board Can. | Journal of the Fisheries Research Board of Canada |
| J. Great Lakes Res. | Journal of Great Lakes Research |
| J. Minn. Acad. Sci. | Journal of the Minnesota Academy of Sciences |
| J. Water Pollut. Control Fed. | Journal of the Water Pollution Control Federation |
| Nat. Hist. | Natural History |
| Prog. Fish-Cult. | Progressive Fish-Culturist |
| Toxicol. Appl. Pharmacol. | Toxicology and Applied Pharmacology |
| Trans. Am. Fish. Soc. | Transactions of the American Fisheries Society |
| Water Res. | Water Research |

## sources

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|---|---|
| ERL-D | Environmental Research Laboratory-Duluth<br>U.S. EPA<br>6201 Congdon Blvd.<br>Duluth, MN 55804 |
| LLRS | Large Lakes Research Station<br>9311 Groh Road<br>Grosse Ile, MI 48138 |
| NTIS | National Technical Information Service<br>5285 Port Royal Road<br>Springfield, VA 22151 |

## HOW TO ORDER

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| WHEN ORDERING FROM NTIS: | Give author, title and either EPA number or Citation from the journal. NTIS may charge a fee for their services. |

# RESEARCH REPORTS

Reports in this section, published by the Agency in its own report series, provide a complete public record of the research activities funded by the Environmental Research Laboratory-Duluth. Consequently, the authors of these reports include not only the Laboratory staff members, but also those scientists at universities, in industry, and at other facilities who receive funding and perform research under the direction of the Environmental Research Laboratory-Duluth.

## 1978

Armitage, Brian J., Thomas D. Forsythe, Elizabeth B. Rodgers, and William B. Wrenn. 1978. Browns Ferry Biothermal Research Series I. Colonization by periphyton, zooplankton, and macroinvertebrates. Contract No. TV-35013A. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-020. 54 p.

Colonization studies on a series of 12 outdoor experimental channels supplied with water from Wheeler Reservoir (Tennessee River) were completed at the Browns Ferry Biothermal Research Station in Alabama. Species composition, dominance, seasonal patterns, colonization rates, and biomass estimates were determined over a 24-month period for periphyton, zooplankton, and macroinvertebrates. The periphyton assemblages were highly productive and diverse. Colonization of bare surfaces was extremely rapid during summer months. Zooplankton was abundant and was composed primarily of shallow-water forms. Macroinvertebrates quickly colonized the biothermal channels by way of inflowing reservoir water and by air. Macroinvertebrate diversity was as great as or greater than that in Wheeler Reservoir and represented taxa found in both littoral and open-water areas. In general, the species composition and the relative densities of algal and invertebrate organisms that colonized the channels indicated that the channels successfully simulate reservoir ecosystems for those trophic levels.

SOURCE: ERL-D

Baril, Steven F., Robert J. Leudtke, and George R. Roemhild. 1978. Environmental effects of western coal combustion Part II - The aquatic macroinvertebrates of Rosebud Creek, Montana. Grant No. R803950. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-099. 85 p.

The aquatic macroinvertebrates of Rosebud Creek, Montana, were sampled between February 1976 and March 1977 to provide data on their abundance, distribution, and diversity. The sampling program was initiated during the first year of operation of the coal-fired power plants located at Colstrip, Montana. The purpose of the study was to determine if any immediate impacts of the power plant operation on the macroinvertebrate communities of Rosebud Creek could be detected and to provide data for comparisons with future studies.

Rosebud Creek supported a diverse bottom fauna with high population numbers composed of species adapted to the turbid, silty conditions which are common in the prairie streams of eastern Montana. Intact riparian vegetation appeared to be important in maintaining stream bank stability and provided an essential food source.

It was concluded that faunal varition among sampling stations during the study period was attributable to physical factors including turbidity, water temperature, current velocity, and substrate, and not to potential impacts from coal mining and combustion.

SOURCE: ERL-D

Canton, Steven P., and James V. Ward. 1978. Environmental Effects of Western Coal Surface Mining Part II - The aquatic macroinvertebrates of Trout Creek, Colorado. Grant No. R803950. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-095. 73 p.

A study was conducted on Trout Creek in northwestern Colorado to assess effects of coal mine drainage on stream macroinvertebrates. Density and biomass exhibited a general increase in the downstream direction throughout the study area and showed marked seasonal variation. Aquatic insects comprised over 90% of the fauna with caddisflies (Trichoptera) predominating. Diversity did not vary significantly throughout the study area. None of the parameters measured showed any definite indication of stressed conditions in the macroinvertebrate community during the study period. Water quality was diminished primarily during spring runoff and the invertebrates seemed able to withstand this short period of water quality degradation. The buffer zone present between the mine area and Trout Creek may decrease the effects of mine drainage and should remain to insure the maintenance of a stable macroinvertebrate community in Trout Creek.

SOURCE: ERL-D

Cole, Richard Allen. 1978. Larval fish distributions in southwestern Lake Erie near the Monroe Power Plant. Grant No. R804517010. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-069. 73 p.

This paper presents and discusses studies of larval fish distribution near a large power plant on western Lake Erie using methods that attempt

to account for the confounding effect of environmental variation on technique effectiveness. Distributions in the coastal zone were sampled with daytime and nighttime tows of 1-m plankton nets. Density and mortality were also sampled in the cooling system of the Monroe Power Plant. It is concluded that prolarvae were concentrated in specific areas near spawning sites, but larvae that reached the lake proper are rapidly dispersed by currents. Although flooded tributaries may act as important concentration points for certain species, no concentration gradients persisted in the lake proper. Certain species of larvae seemed to be more vulnerable to entrainment than others; gizzard shad were more vulnerable than yellow perch, white bass, rainbow smelt, shiners (Notropis) carp and goldfish.

SOURCE: LLRS

Cole, Richard Allen. 1978. Entrainment at a once-through cooling system on western Lake Erie. Grant No. R801188. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-070. 154 p.

This study assessed entrainment rates and effects for important components of the aquatic community in the once-through cooling system of a steam-electric power plant (the Monroe Power Plant), which can draw up to $85^3$ m/second of cooling water from Lake Erie (~80%) and the Raisin River (~20%). Phytoplankton, periphyton, zooplankton, ichthyoplankton, and community metabolism were sampled bimonthly from November 1972 through September 1975. Sampling was conducted at fixed locations in the intake region, discharge canal, thermal plume and the lake-source waters. Concentrations of chloride, dissolved and total solids were used to trace water masses and their associated nutrient and plankton concentrations. At temperatures above 15°C in the discharge canal, photosynthesis was depressed and community respiration was accelerated. Algal abundance increased slightly as green and bluegreen algae increased more than other taxa during passage, but algal diversity remained basically unchanged.

Although zooplankton densities declined about 40% in the cooling system, diversity remained unchanged and the impact was masked by mixing in the receiving waters. Larval fish were concentrated near bottom at night and moved up from bottom during the day. Geographical and temporal variation in larval fish distribution were great, but certain species seemed most abundant offshore while others were concentrated near shore.

SOURCE: LLRS

Cole, Richard Allen. 1978. Entrainment at a once-through cooling system on Lake Erie, Volume II, Appendices. Grant No. R801188. U.S. Environmental Protection Agency, Duluth, MN. NTIS Only Report - EPA-600/3-78-077. 256 p.

This is an appendix to a report entitled "Entrainment at a once-through cooling system on Lake Erie". It presents tables and figures that provide background material for that report.

SOURCE: NTIS PB 287 934/AS

Elser, Allen A., and James C. Schreiber. 1978. Environmental effects of western coal combustion Part I - The fishes of Rosebud Creek, Montana. Grant No. R803950. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-098. 42 p.

Fish populations have been studied during 1975 and 1976 in Rosebud Creek, a prairie stream which flows through the Fort Union Coal Basin in southeastern Montana. The objective of this study was to collect fish population data to determine any immediate effects, and to act as a yardstick for assessing possible future effects of accelerated activities of coal mining and coal combustion in this region.

Fishes were inventoried at nine stations and included 21 species representing nine families. The species composition and fish distribution were representative of other streams in this region. Game fishes included northern pike found throughout the stream, brook trout which occurred in the headwater areas, and sauger, walleye, channel catfish, and burbot which were found near the confluence with the Yellowstone River. The most abundant nongame species were white sucker and shorthead redhorse. Fish species diversity increased in a downstream direction, and tributaries contained many of the same fish species as in Rosebud Creek. The seasonal occurrence of reproductively mature game fishes in the lower region of Rosebud Creek suggests that it is used for spawning by fishes from the Yellowstone River.

During the study, there was no apparent effect of either coal mining or coal combustion activities on the distribution of fishes in Rosebud Creek.

SOURCE: ERL-D

Environmental Protection Agency - U.S.A., and Soviet Academy of Sciences - U.S.S.R. 1978. Proceedings of the first and second USA-USSR symposia on the effects of pollutants upon aquatic ecosystesm, Volume I - Duluth, Minnesota, USA Symposium - October 21-23, 1975 (Donald I. Mount, ed.), Volume II - Borok, Jaroslavl Oblast, USSR Symposium - June 22-26, 1976 (Wayland R. Swain and Nina K. Ivanikiw, eds). U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-78-076. 412 p.

This publication represents the proceedings of two symposia conducted jointly by the U.S. EPA and the Academy of Sciences of U.S.S.R. The first symposia (Volume I) was held in Duluth, Minnesota, USA on October 21-23, 1975, and the second (Volume II) was held in Borok, Jaroslavl Oblast, USSR during June 22-26, 1976. The published papers from these symposia contain both broadly based review papers, designed to familiarize attendees with a wide cross-sectional representation of ecologically related activities in each country, and narrowly

specific state-of-the-art scientific discussions. The presentations focus upon methodology, historical aspects, microbial and abiotic degradation processes, trace metal problems, effects of toxicants, proposed species indices, and studies of fate and transport of pollutants.

SOURCE: LLRS

Goettl, John P., Jr., and Jerry W. Edde. 1978. Environmental effects of oil shale mining and processing Part I - Fishes of Piceance Creek, Colorado, prior to oil shale processing. Grant No. R803950. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-096. 27 p.

The fish populations of Piceance Creek, Colorado, were surveyed to establish preoperational conditions prior to extensive oil shale processing in the region. Data collected in this study have been compared to data reported by earlier researchers.

The mountain sucker (Catostomus platyrhunchus) and the speckled dace (Rhinichthys osculus) are the most abundant and widespread fishes found in Piceance Creek. Numbers of all species were not great; the largest number of fish captured per 100 meters of stream was 76 individuals, while the range for all other stations was 3-23 fish/100 m. Brook, brown, and rainbow trout (Salvelinus fontinalis, Salmo trutta, and Salmo gairdneri, respectively) were most common in the upper reaches of Piceance Creek in its tributaries, Black Sulphur Creek and Stewart Creek. Results of our survey indicate that brook and brown trout are reproducing naturally in Piceance Creek but rainbow trout are doing poorly.

The introduction of species from other drainages and the effects of agricultural diversions and riparian alterations have produced recent changes in the fish fauna of Piceance Creek. Possible impacts of oil shale processing on the fish populations of Piceance Creek are suggested.

SOURCE: ERL-D

Gray, Lawrence J., and James V. Ward. 1978. Environmental effects of oil shale mining and processing Part II - The aquatic macroinvertebrates of the Piceance Basin, Colorado, prior to oil shale processing. Grant No. R803950. U.S. Environmental Protection Agency. Publication EPA-600/3-78-097. 48 p.

A study was conducted at sampling sites on four streams in the Piceance Basin of northwestern Colorado to acquire data on benthic macroinvertebrate communities prior to commencement of oil shale mining and processing activities. Piceance Creek, the major stream studied, exhibited considerable longitudinal variation in environmental conditions. Sodium, sulfate, chloride, and total dissolved solids increased greatly in the downstream direction. The temperature range, turbidity, severity of winter ice conditions, and effects of grazing and irrigation activities

also increased downstream. Downstream reductions in density, biomass and diversity, and altered macroinvertebrate species composition were associated with the longitudinal changes in environmental parameters. The fauna of upstream areas of Piceance Creek and its tributaries was composed of primarily winter species (those that complete their life cycle from fall to spring), whereas the fauna of downstream reaches of Piceance Creek was composed almost entirely of summer species. Effects of oil shale mining and processing activities on aquatic biota will depend upon the type of mining employed, the extent of surface and subsurface disturbance, the success of pollution controls, points of pollution entry, and extent of water depletion. Present environmental conditions and macrinvertebrate communities of the lower reaches of Piceance Creek may be indicative of the potential effect of future impacts at upstream locations.

SOURCE: ERL-D

Holcombe, Gary W., and Robert W. Andrew. 1978. The acute toxicity of zinc to rainbow and brook trout - Comparisons in hard and soft water. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-094. 25 p.

The means and ranges of the 96-hour LC50's derived from three tests were 0.55 (0.37 to 0.76) and 2.5 (1.9 to 3.0) mg Zn/liter for rainbow and 2.0 (1.6 to 2.4) and 6.0 (5.0 to 7.0) mg Zn/liter for brook trout in soft and hard water, respectively. Based on overall means, brook trout were approximately 2.7 times more resistant than rainbow trout. Zinc toxicity to both species increased with increasing pH, and decreased with increasing hardness and alkalinity.

SOURCE: ERL-D

Larson, Gary L., Charles E. Warren, Floyd E. Hutchins, Larry P. Lamperti, David A. Schlesinger, and Wayne K. Seim. 1978. Toxicity of residual chlorine compounds to aquatic organisms. Grant No. R802286. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-023. 117 p.

Laboratory studies on the acute and chronic toxicity of chlorine and inorganic chloramines to trout, salmon, minnows, bullhead, largemouth bass, and bluegill were conducted. Acute toxicity under continuous and intermittent patterns of exposure as well as behavioral, reproduction, development, and growth responses to low level exposures to residual chlorine compounds were determined. But not all patterns of toxicant exposure or all responses of all fish species were studied. Acute and chronic toxicities of chloramines to crayfish were investigated. Algae, invertebrates, including insects, and juvenile salmon were exposed continuously to relatively low levels of residual chloramine compounds in laboratory stream communities. The acute toxicities of inorganic chloramines, as measured by 96-hr LC50 values, were less than 100 µg/l for salmonids and were a function of life history

stage, body size and some water quality conditions. Whereas adult trout may live indefinitely at concentrations near 50 µg/l, the LC50 values for late developmental stages---fry and very small juveniles ---were not much above this concentration. Effects on growth of alevins and juveniles had threshold concentration values between about 10 and 22 µg/l, effects being quite marked at 22 µg/l. In intermittent exposure to relatively high concentrations of free residual chlorine, mortality was found to be a rather consistent function of the area under the time-concentration curves of exposure, for different forms, durations, and frequencies of such patterns of exposure. Behavioral responses of fish, such as avoidance of chlorinated water which could be advantageous in nature and lethargic swimming, surfacing, and sinking to the bottom which would probably be harmful were studied. Such behaviors occur not only at acutely toxic concentrations but also at lower ones. It was necessary to introduce concentrations ranging from 100 to 800 µg/l of chloramine into laboratory stream communities to maintain mean residual concentrations of near 20 µg/l. No marked effects on algal or insect abundances or on survival and production of juvenile salmon were observed at this and lower concentrations in the laboratory streams. It is doubtful that the amperometrically determined residual concentrations of chloramines in the streams consisted predominantly of inorganic chloramines, organic chloramines, perhaps being an important constituent under the stream conditions. Little is known of the toxicity of organic chloramines. The amount of inorganic chloramines introduced to maintain desired residual concentrations appears to have been a function of the amount of organic material in the stream communities.

SOURCE: ERL-D

Lemke, A.E., W.A. Brungs, and B.J. Halligan. 1978. Manual for construction and operation of toxicity-testing proportional diluters. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-072. 78 p.

This paper presents a discussion of the testing procedures using proportional diluters. The construction, calibration, and operation of the equipment is explained, and trouble shooting techniques necessary for successful use of such equipment are given.

A bibliography includes many related pubished materials that are not discussed in the text but which should be useful to the reader. Included are numerous citations on physical toxicity testing methods, but papers on statistics or biological test procedures are not included.

SOURCE: ERL-D

Mount, Donald I. 1978. Measuring aquatic impact of toxic contaminants. In: Proceedings of the Second Open Forum on Management of Petroleum Refinery Wastewater, March 1978. Publication EPA-600/2-78-058. pp. 185-192.

The increasing frequency of problems with toxic, often organic, chemicals has focused attention on finding better and more rapid methods of measuring impact. The accumulation of body burdens in edible fishes to unacceptable concentrations is the most significant effect in some instances. Teratogenicity and carcinogenicity do not have special or emotional significance or effect on aquatic systems as they do for human populations. Care must be exercised to assure that toxicity is not substituted for environmental hazard when effects of chemicals are evaluated. Reliable, rapid tests are available for measuring toxicity of aquatic organisms.

SOURCE: ERL-D

Murphy, Thomas J., and Charles P. Rzeszutko. 1978. Polychlorinated Biphenyls in precipitation in the Lake Michigan basin. Grant No. 803915. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-071. 39 p.

Rainfall samples were collected in Chicago, Illinois, and on Beaver Island, Michigan, and analyzed for polychlorinated biphenyls (PCBs). The precipitation weighted mean concentration of 35 samples of rain was 111 ng/l (111 parts per trillion). This would result in the deposition of 4800 kg/yr of PCBs to the lake from precipitation. Presently available evidence on other sources of PCBs to the lake indicates that precipitation is now the major source of PCBs to the lake. The future PCB problems in the lakes will then be determined mainly by the magnitude of atmospheric inputs to the lake.

The concentrations of PCBs in rainfall were found to be as high on Beaver Island as in Chicago.

Results obtained from the simultaneous sampling of air and precipitation indicate that PCBs are present in the atmosphere as vapor as well as being present on particulates. This result raises doubts as to the validity of results for the dry deposition of PCBs obtained from the use of collectors covered with mineral oil or other non-polar liquid.

PCB concentrations in the parts per billion range obtained from gas samples from a vented sanitary landfill, indicate that PCB containing minerals incorporated into landfills may be an important source of PCBs to the atmosphere.

SOURCE: ERL-D

Phillips, Glenn R., and Rosemarie C. Russo. 1978. Metal Bioaccumulation in fishes and aquatic invertebrates: A literature review. Grant No. R803950. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-103. 121 p.

Literature concerning the bioaccumulation of metals by freshwater and marine fishes and invertebrates has been reviewed; metal residue levels are also reported for a few mammals and plants. Twenty-one metals are considered in individual sections of the review and a bibliography of over 300 literature citations is included.

The major sources of each metal to the environment are listed as are the causes and symptoms of metal toxicity in humans. Some discussion is included on the health implications of human consumption of metal-contaminated aquatic organisms. Available information is presented on: routes of accumulation, kinetics of accumulation and excretion, distribution within organisms, physiological responses of organisms, residue-toxicity thresholds, chemical speciation relative to biological availability, and microbial and chemical interconversions in aqueous systems. Major areas of insufficient knowledge are identified.

Few metals accumulate in the edible portions of aquatic organisms; moreover, most metals when ingested orally have a relatively low toxicity to humans. However, mercury, arsenic, and radioactive cesium may reach hazardous concentrations in edible tissues of fishes and shellfishes; additionally, in shellfishes, cadmium, lead, and other metal isotopes may exceed levels safe for human consumption.

SOURCE: ERL-D

Swenson, William A. 1978. Influence of turbidity on fish abundance in western Lake Superior. Grant No. R802455. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-067. 92 p.

This research project was developed to improve understanding of the influence of turbidity on fish populations and the mechanism through which its effects are induced.

Field and laboratory studies emphasized measurement of behavioral response of fish and resulting changes in fish species interrelationships in western Lake Superior. Direct effects of red clay turbidity on survival and growth of larval lake herring (Coregonus artedii) were also measured.

Field measurements demonstrated that light penetration in western Lake Superior is reduced significantly even at very low levels of red clay turbidity. Zooplankton abundance and distribution was highest near the surface in red clay plumes. Smelt (Osmerus mordax) move into the upper 12 m of water in response to turbidity where their predation on larval fish increases. Predation by smelt on larval lake herring was identified as a factor contributing to the decline of the formerly abundant western Lake Superior lake herring population and the commercial fishery which depended upon it.

Walleye (Stizostedion vitreum vitreum) and lake trout (Salvelinus namaycush) demonstrated opposite responses to turbidity. Walleye

concentrated in turbid water where food availability was apparently greater. Lake trout showed partial avoidance to turbidity in the lake and in laboratory turbidity gradients.

SOURCE: ERL-D

Thomann, Robert V. 1978. Size dependent model of hazardous substances in aquatic food chain. Contract No. R803680030. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-036. 47 p.

In order to incorporate both bioaccumulation of toxic substances directly from the water and subsequent transfer up the food chain, a mass balance model is constructed that introduces organism size as an additional independent variable. The model represents an ecological continuum through size dependency; classical compartment analyses are therefore a special case of the continuous model. Size dependence is viewed as a very approximate ordering of trophic position.

The analysis of some PCB data in Lake Ontario is used as an illustration of the theory. A completely mixed water volume is used. Organism size is considered from 100 μm to $10^6$ μm. PCB data were available for 64 μm net hauls, alewife, smelt, sculpin and coho salmon. Laboratory data from the literature were used for preliminary estimates of the model coefficients together with the field data. The analysis indicated that about 30% of the observed 6.5 μg PCB/gm fish at the coho salmon size range is due to transfer from lower levels in the food chain and about 70% from direct water intake. The model shows rapid accumulation of PCB with organism size due principally to decreased biomass at higher trophic levels. The analysis indicates that if a level of 5 μg PCB/gm at $10^6$ μm is sought, total (dissolved and particulate) water concentration would have to be about 36 ng/l or about 66% of the present 55 ng/l.

SOURCE: ERL-D

Tucker, James H., Philip M. Cook, Gary L. Phipps, Gertrude N. Stokes, and Paul H. Lima. 1978. Asbestos - A bibliography. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-066. 98 p.

This bibliography contains 1,425 references pertaining to the chemical, physical, biological, and medical properties and effects of asbestos in our environment. The bibliography was compiled by the asbestos research group at the Environmental Research Laboratory-Duluth, Duluth, MN.

SOURCE: ERL-D

Veith, Gilman D., and Richard T. Morris. 1978. A rapid method for estimating log P for organic chemicals. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-78-049. 24 p.

A rapid, inexpensive technique based on reverse-phase high pressure liquid chromatography has been developed to estimate the n-octanol/water partition coefficient of organic chemicals. The system consists of a preparative Micro-Pak C-10 reverse-phase column eluted with a 15 percent water/85 percent methanol solvent flowing at 2 ml/min at room temperature. The chemicals are detected in the eluant with a standard ultraviolet detector or a fraction collector system followed by appropriate analysis of the fractions to determine the retention time of the chemical. A linear calibration of the logarithm of retention time with the logarithm of the partition coefficient (Log P) is attained by using a mixture of benzene, bromobenzene, biphenyl, bibenzyl, pp'DDE, and 2,4,5,2',5' pentachlorobiphenyl as reference standards of known Log P. Chemicals with Log P of approximately 3 elute in less than 10 minutes whereas those with Log P greater than 5 elute after 20 minutes.

SOURCE: ERL-D

# 1977

Allison, Donald T. 1977. Use of exposure units for estimating aquatic toxicity of organophosphate pesticides. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-077. 33 p.

Environmental water concentrations of organophosphate pesticides can be expected to fluctuate widely due to use patterns and rapid hydrolysis. This study investigated some relationships of exposure concentration, duration and periodicity to the chronic toxicity of diazinon to flagfish (Jordanella floridae). Effects were compared on the basis of "exposure units" (exposure concentration x exposure duration). Treatments at equivalent exposure units caused similar overall effects on the test populations regardless of the life stages exposed or exposure duration per se. The hypothesis is proposed that exposure units could be used to estimate the environmental impact of fluctuating water concentrations of organophosphate pesticides over a wide range of concentration, duration and periodicity.

SOURCE: NTIS PB 272 796/4BE

Allison, Donald T., and Roger O. Hermanutz. 1977. Toxicity of diazinon to brook trout and fathead minnows. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-060. 77 p.

Average 96-hr LC50's for diazinon under flow-through conditions were 7.8, 1.6, 0.77, and 0.46 mg/l, respectively, for fathead minnows, flagfish, brook trout, and bluegills.

The chronic effects of diazinon on fathead minnows and brook trout were determined in flow-through systems with constant toxicant concentrations. Fathead minnows exposed to the lowest concentration tested (3.2 µg/l) from 5 days after hatch through spawning had a significantly higher incidence of scoliosis than the control (P = 0.05). Hatch of their progeny was reduced by 30% at this concentration. Yearling brook trout exposed to 4.8 µg/l and above began developing scoliosis and lordosis within a few weeks. Growth of brook trout was substantially inhibited during the first 3 months at 4.8 µg/l and above. Neurological symptoms were evident in brook trout at 2.4 µg/l and above early in the tests, but were rarely observed after 4 or 5 months of exposure. Exposure of mature brook trout for 6-8 months to concentrations ranging from 9.6 µg/l to the lowest tested (0.55 µg/l) resulted in equally reduced growth rates for their progeny. Transfer of progeny between concentrations indicated that effects noted for progeny of both species at lower concentrations were the result of parental exposure alone and not the exposure of progeny following fertilization.

SOURCE: ERL-D

Brungs, William A., and Bernard R. Jones. 1977. Temperature Criteria for Freshwater Fish: Protocol and procedures. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-77-061. 136 p.

Temperature criteria for freshwater fish are expressed as mean and maximum temperatures; means control functions such as embryogenesis, growth, maturation, and reproductivity, and maxima provide protection for all life stages against lethal conditions. These criteria for 34 fish species are based on numerous field and laboratory studies, and yet for some important species the data are still insufficient to develop all the necessary criteria. Fishery managers, power-plant designers, and regulatory agencies will find these criteria useful in their efforts to protect fishery resources.

SOURCE: ERL-D

Buikema, Arthur L., Jr., John Cairns, Jr., Paul C. Edmunds, and Thomas H. Krakauer. 1977. Culturing and Ecology Studies of the Rotifer, Polyarthra vulgaris. Grant No. R800815. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-051. 64 p.

The results contained in this report represent research conducted to identify variables which affect the survival and reproduction of the rotifer, Polyarthra vulgaris. The following variables were studied: handling stress, container size, frequency of changing the culture medium, light quantity and quality, photoperiod, oxygen and vitamin requirements, fungal parasites, food preference and concentration, antibiotic affects of bluegreen algae, and temperature.

Temperature had an effect on population dynamics, percent of females with eggs, number of eggs per female, and sexual reproduction. Egg production rates were estimated and observations on the duration of egg development were made.

This report also includes a field study of the relation between Polyarthra vulgaris and 19 selected chemical and physical parameters.

SOURCE: ERL-D

Cardwell, Rick D., Dallas G. Foreman, Thomas R. Payne, and Doris J. Wilbur. 1977. Acute and chronic toxicity of chlordane to fish and invertebrates. Contract No. 68-01-0187. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-77-019. 136 p.

The acute and chronic toxicity of technical chlordane to bluegill (Lepomis macrochirus), fathead minnow (Pimephales promelas), brook trout (Salvelinus fontinalis), Daphnia magna, Hyallela azteca and Chironomus No. 51 were determined with flow-through conditions. The purpose was to estimate concentrations producing acute mortality and those having no effect on the long-term survival, growth and reproduction of the various species. Whole body residues of technical chlordane components were measured in the three invertebrates species at the end of the chronic exposure tests. Concentrations of technical chlordane causing 50% mortality in 96-hr were 36.9 µg/l for fathead minnow, 47 µg/l for brook trout and 59 µg/l for bluegill, while that causing 50% immobilization in the cladoceran, D. magna, was 28.4 µg/l. The amphipod, H. azteca, was only slightly affected at 96-hr by the chlordane concentrations tested, and the 168-hr EC50 was 97.1 µg/l. Acute mortality of midges, Chironomus No. 51, was not successfully evaluated. With respect to the test conditions employed and life cycle stages evaluated the lowest concentrations of technical chlordane found to cause major chronic effects were 0.32 µg/l for brook trout, 1.22 µg/l for bluegill, 1.7 µg/l for midges, 11.5 µg/l for amphipods and 21.6 µg/l for cladocerans.

SOURCE: ERL-D

Carlson, Robert M., and Ronald Caple. 1977. Chemical/biological implications by using chlorine and ozone for disinfection. Grant No. R-800675. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-066. 96 p.

Chlorine is readily incorporated into a variety of organic materials known to be present in water subjected to chlorine-renovation procedures. The observed products can be predicted on the basis of commonly used mechanistic considerations. The aqueous ozonation studies confirm that mechanistic considerations developed in non-aqueous cases can be applied to the prediction of products from ozone addition to dilute solutions of unsaturated organics in water.

The dominant feature in the observed toxicity of phenols to Daphnia magna was the lipophilic nature of the compound as represented by the partition coefficient. The partition coefficient of a compound has been shown as part of this overall study to be readily obtained from its retention properties on a "reverse-phase" HPLC column.

The effects of chlorination on biological oxygen demand (BOD) were examined by comparing the BOD requirements of a sample containing a given parent system vs that of its chlorinated progeny. The results indicate that the chlorinated material is generally degraded less than the parent and that the lowered BOD values appear, at least for phenols, to be associated with the increased toxicity of the chlorinated material to the degrading organism.

SOURCE: ERL-D

Cowen, William F., Kannikar Sirisinha, and G. Fred Lee. 1977. Algal nutrient availability and limitation in Lake Ontario during IFYGL. Part II. Nitrogen available in Lake Ontario tributary water samples and urban runoff from Madison, Wisconsin. Contract No. R-800537-02. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-045. 100 p.

Samples of water from the Niagara, Genesee, Oswego and Black Rivers were collected from March to June 1973. The samples were analyzed for nitrogen forms and were incubated in darkness under aerobic conditions to promote mineralization of soluble inorganic nitrogen from the organic nitrogen in the samples. The amounts of ammonia and nitrate were determined as a function of the time of incubation. Generally over 50 percent of total nitrogen present in these river samples was immediately available for algal growth or potentially available after mineralization by bacteria. The results were highly variable from each tributary, and no single value could be selected from the data obtained to describe the availability of total nitrogen in a given river.

SOURCE: LLRS

Delumyea, Richard G., and Resy L. Petel. 1977. Atmospheric input of phosphorus to southern Lake Huron, April-October 1975. Grant No. R803086. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-77-038. 62 p.

The input of phosphorus has been demonstrated to be seasonally dependent. Of the total input, approximately half is potentially available, and one-fourth is immediately available. Inputs due to wet and dry deposition are roughly equal in magnitude. The major source appears to be agriculture with at least 10% due to combustion sources. A model for particulate deposition was used to determine the deposition velocity of phosphorus containing particles. The value of 0.6 cm/sec is considered applicable to other components whose mean diameter is 1 μm.

SOURCE: LLRS

Drummond, Robert A. and Richard W. Carlson. 1977. Procedures for measuring cough (gill Purge) rates of fish. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-77-133. 55 p.

The cough (gill purge) is an interruption in the normal ventilatory cycle of fish that serves to clean the gills of accumulated particulate matter. A review of the literature shows that the cough occurs in a variety of freshwater and marine fish; that both mechanical and chemical stimulation apparently can cause fish to increase their cough rates; and that an increase in coughing is a rapid and sensitive endpoint for studying chemicals and effluents. In reviewing the test methods and apparatus for measuring cough rates of fish, we conclude the electrode chamber method offers more potential as a bioassay tool for assessing the respiratory responses of fish due to toxicant exposure. Recommended test procedures, based on our experience, for using the electrode chamber method are given.

SOURCE: ERL-D

Fromm, Paul O. 1977. Toxic effect of water soluble pollutants on freshwater fish. Grant No. R-801034. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-057. 63 p.

Studies of the effect of inorganic and organic mercury on trout indicated that uptake was primarily via the gills in non-feeding fish. Organic mercury entered fish at a faster rate than inorganic mercury. Exposure of trout to 10 µg Hg/l (methyl form) had no effect on the gill oxygen consumption measured in vitro or on the plasma electrolytes. The hematocrit index increased significantly. Studies of the metabolism of iron by normal and iron deficient trout (made deficient by bleeding) indicated that the liver, spleen, and head kidney are the major iron storage organs. Liver iron was reduced by bleeding whereas splenic iron was unaffected. In iron deficient fish more radio iron appeared in eurythrocytes than in normal controls. Studies of isolated-perfused gills revealed the presence of both α and β adrenergic receptors and the data obtained indicate the functional surface area of trout gills can be regulated by changes in perfusion pathway through the gills. Use of perfused gills appears to be a very sensitive model to detect deleterious action of pollutants on fish. Evaluation of heat exchange in perfused gills indicates that the presence of epinephrine increased administration of acetylcholine. Analysis of a simple model indicated that the gills may account for as much as 60% of the total heat exchanged by trout.

SOURCE: ERL-D

Jahoda, Joseph R. 1977. Instrumentation to monitor location of fish continuously in experimental channels. Contract No. 68-01-0752. U.S.

Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-035. 128 p.

This study resulted in the development and construction of equipment to continuously monitor the position and temperature of up to 20 fish in a water channel 486 meters long, three meters wide and one meter deep. The system utilized miniature sonic transmitters (tags) operating in the 51 kHz to 366 kHz frequency range which were implanted in 500 gram or heavier fish. The battery operated tags were pulse modulated and designed for over one year operational life. A temperature sensitive thermistor controlled the repetition rate of the tag providing the temperature of the fish to an accuracy of one degree C. The nominal range of the polyurethane encapsulated tag was several hundred feet. Nominal tag size was 16 mm OD x 32 mm long (4.6 - 5.4 g in water). Sixteen hydrophones were located at 30.5 meter intervals in the water channel. A control console contained a manually-operated, frequency-stepped receiver which could select any individual hydrophone, thus locating the fish to within ± 5.25 meters. Up to 20 individual fish could be monitored. Automatic operation and recording of the data was considered in the design of the system for future equipment. Severe radio frequence interference problems were encountered requiring extensive precautions and modification of the channel equipment and wiring. Also investigated were passive fish monitoring and tracking of small fish fry. An experimental system was completed for limited monitoring applications.

SOURCE: ERL-D

Mancy, K.H., and H.E. Allen. 1977. A controlled bioassay system for measuring toxicity of heavy metals. Contract No. 14-12-591. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-037. 121 p.

Biological availability of metal micronutrients and metal toxicity are believed to be dependent on metal oxidation state, complexation and solubility as well as physiocochemical characteristics of the aqueous phase. Basic design criteria for fish bioassays which are capable of elucidating the dependency of toxicity on the type and concentration of various copper species were developed utilizing equilibrium chemical concepts and appropriate analytical techniques. In order to maintain a desired copper species in the bioassay medium, synthetic waters were used under well defined physical and chemical conditions. These solutions were synthesized in accordance with equilibrium models, which define the distribution of various copper species as a function of the solution physical and chemical characteristics. An experimental system was developed which permitted large volumes of the bioassay waters to be maintained at the desired chemical equilibria for the duration of the experiment.

Monitoring of the bioassay system included measurements of (a) pH, (b) temperature, (c) flow, (d) specific conductance, (e) calcium, (f) total

alkalinity, (g) dissolved oxygen, and (h) copper species. Novel analytical procedures were applied for the measurement and the differentiation of copper species. This included the use of anodic stripping voltammetry and potentiometric membrane electrodes.

SOURCE: ERL-D

Mayer, Foster L., Jr., Paul M. Mehrle, Jr., and William P. Dwyer. 1977. Toxaphene: Chronic toxicity to fathead minnows and channel catfish. Contract No. EPA-IAG-141(d). U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-069. 49 p.

Fathead minnows (Pimephales promelas) and channel catfish Ictalurus punctatus) were continuously exposed to several toxaphene concentrations (13-630 ng/l) in flow-through diluter systems for 8 to 10 months.

Growth and backbone quality of adult fathead minnows were decreased at 97 and 173 ng/l exposures, but adult channel catfish were not affected by toxaphene. Effects on reproduction were observed only in channel catfish in the 630 ng/l concentration: the period from pairing to spawning was increased and the amount of gelatinous matrix surrounding the eggs was reduced. Survival of fathead minnows was not affected by toxaphene, but the no-effect-concentration for fry growth and bone quality was below 54 and 97 ng/l, respectively. Channel catfish fry survival and growth were reduced in the 299 and 630 ng/l exposures, and bone quality was altered in concentrations as low as 72 ng/l. The maximum toxaphene accumulation from water to fish was 69,000 times in fathead minnows and 50,000 times in channel catfish. Toxaphene was excreted very slowly in both species.

SOURCE: ERL-D

McCauley, Robert W. 1977. Seasonal effects on temperature preference in yellow perch, Perca flavescens. Grant No. R802467. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-088. 33 p.

Seasonal variations in temperature preferences of adult yellow perch (Perca flavescens) were sought by acclimating fish captured in the fall to 5, 10, 15, and 20C in the laboratory and determining their preferred temperatures in a horizontal temperature gradient trough. Temperatures selected in winter for fish acclimated to 5C ranged from 12 to 14C, considerably above the temperature region (6C and below) previously established for optimum gametogenesis. Final preferenda as determined from preferred temperature-acclimation temperature curves were 24, 20 and 17C during winter, spring and summer respectively. Those in late summer were below published values (23.5C) for this species. It is concluded that there are no demonstrable effects, at least in winter and early spring which might reflect changing physiological needs and that temperature gradients in nature serve rather to attract perch to warm

temperatures suitable for spawning in spring and conducive to growth in summer.

SOURCE: ERL-D

McCormick, J. Howard. 1977. Effects of temperature on hatching success and survival of larvae in the white bass. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-075. 19 p.

To determine temperature effects on hatching success of white bass (Morone chrysops) embryos, sample lots of fertilized eggs were exposed to 10 constant temperatures, 6° through 30°C. Exposures were begun at two stages of embryonic development, before gastrulation and after closure of the blastopore. Embryos exposed before gastrulation were more sensitive to extreme temperatures than those exposed after closure of the blastopore. The percentage of normal larvae hatched from embryos exposed before gastrulation was not significantly impaired over the temperature range 18° - 26°C (P 0.05). When first exposed after blastopore closure the range of temperatures allowing unimpaired hatching was extended to 14° - 28°C (P 0.05). Normal larvae hatched at 14° - 28°C from embryos exposed before gastrulation and at 10° - 28°C when exposed after blastopore closure, but at the extreme in significantly reduced numbers (P 0.05). Hatching took place 4.5 days after fertilization when incubated at 14°C and 1 day after fertilization at 26°C.

The 24-hr TL50 for white bass larvae exposed within 24 hr of hatching and acclimated at temperatures from 14° - 26° was between 30° and 32°C and was not altered by acclimation.

SOURCE: ERL-D

Nebeker, Alan V., Frank A. Puglisi, and David L. DeFoe. 1977. Toxicity of polychlorinated biphenyls (PCBs) to fish and other aquatic life. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-034. 84 p. NTIS No. PB264804/AS.

Aroclor 1248 was the most toxic of eight aroclors tested with Daphnia magna in static tests, resulting in a 3-week LC50 of 25 µg/liter. Aroclor 1254 was most toxic under continuous-flow conditions with a 3-week LC50 of 1.3 µg/l. The Aroclors were much more toxic under continuous-flow than static conditions, with 16% impairment of reproduction by Aroclor 1248 occurring at 1.0 µg/liter. Calculated 96-hour LC50 values for newly-hatched fathead minnows were 7.7 µg/l for Aroclor 1254 and 15 µg/liter for 1242. Three-month-old fatheads had a 96-hour LC50 of about 300 µg/liter for Aroclor 1242. Reproduction occurred at and below 1.8 µg/liter 1254 and at and below 5.4 µg/liter 1242. Polychlorinated biphenyls were acutely toxic but exhibited much greater chronic toxicity at very low levels due to their cumulative nature. Newly hatched young were the most sensitive life stage. Young fathead growth was also affected above 2.2 µg/liter 1248 and none survived above

5.1 µg/liter after 30 days. Young flagfish, Jordanella floridae, did not survive above 5.1 µg/liter 1248 and did not grow well above 2.2 µg/liter. Ninety-six hour LC50 values for Aroclor 1242 and 1248 with Gammarus pseudolimnaeus were 73 and 29 µg/liter. Survival after 30 days was 53 percent at 8.7 µg/liter 1242 and 52 percent at 5.1 µg/liter 1248. Good reproduction and survival of young occurred at 2.8 µg/liter 1242 and 2.2 µg/liter 1248.

SOURCE: NTIS PB 264 804/AS

Smith, V.E., K.W. Lee, J.C. Filkins, K.W. Hatwell, K.R. Rygwelski, and J.M. Townsend. 1977. Survey of chemical factors in Saginaw Bay (Lake Huron). Grant No. R802685. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-125. 159 p.

Water quality in Saginaw Bay, Michigan (western Lake Huron) was surveyed during 32 cruises in 1974 and 1975, as part of the International Joint Commission's Upper Lakes Reference Study co-sponsored by the United States and Canada. Goals of the study were to establish a base of water quality information and to provide data required to model biological and hydrological processes in the bay. Sampling and in situ monitoring were conducted at 18-day intervals during April-October (coinciding with Landsat satellite passes) and approximately at monthly intervals during November-March.

Samples were collected from several depth levels at 59 stations in 1974 and at a 37-station subset of these 59 stations in 1975. Measurements included: temperature, dissolved oxygen, conductivity, chloride, pH, alkalinity, Secchi depth, chlorophylls, nitrate and phosphate, organic nitrogen, total phosphorus, organic carbon, total solids and major metals. Additional diurnal or daily sampling was conducted at selected stations.

SOURCE: ERL-D

Spehar, Robert L., Gilman D. Veith, David L. DeFoe, and Barbara A. Bergstedt. 1977. A rapid assessment of the toxicity of three chlorinated cyclodiene insecticide intermediates to fathead minnows. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-099. 30 p.

A rapid assessment study to determine the toxicity and bioaccumulation of three chlorinated cyclodiene insecticide intermediates; hexachlorocyclopentadiene, hexachloronorbornadiene, and heptachloronorbornene to fathead minnow larvae and early juveniles was conducted for 30 days under flow-through conditions.

A concentration of 7.3 µg/liter of hexachlorocyclopentadiene caused significant decreases in survival after 4 days. Growth of fish exposed for 30 days was not significantly decreased at any of the concentrations tested. The highest concentration of hexachlorocyclopentadiene having no adverse effect was 3.7 µg/liter.

Concentrations of 122 and 226 µg/liter of hexachloronorbornadiene caused significant decreases in survival after 4 days. Growth of 30-day-old-larvae was significantly decreased at 38.4 µg/liter and was the most sensitive indicator of toxicity. The highest concentration having no adverse effect was 20.0 µg/liter. The average bioconcentration factor for fish exposed to less than 38.4 µg/liter of this compound was 6400.

Survival of fathead minnows exposed to heptachloronorbornene was significantly decreased at 83.5 µg/liter after 4 days. Growth was significantly reduced at 40 µg/liter after 30 days and was the most sensitive indicator of toxicity. The highest concentration having no adverse effect was 25.9 µg/liter. The average bioconcentration factor for fish exposed to less than 40 µg/liter of this compound in water was 11,200.

SOURCE: ERL-D

Sridharan, Nagalaxmi, and G. Fred Lee. 1977. Algal Nutrient Availability and Limitation in Lake Ontario During IFYGL. Part III. Algal nutrient limitation in Lake Ontario During IFYGL. Contract No. R-800537-02. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-046a. 58 p.

This study was conducted on the potential significance of nitrogen, phosphorus and micronutrients in limiting planktonic algal growth in Lake Ontatio and its major tributaries. Standard algal assay procedures were used. Samples of the open waters of Lake Ontario and Niagara River waters collected during the spring showed phosphorus limitation. By late summer these waters showed both nitrogen and phosphorus limitation. Genesee and Oswego Rivers showed, in general, nitrogen limitation. Samples of the Black River Waters showed both nitrogen and phosphorus limitation.

SOURCE: LLRS

Sridharan, Nagalaxmi, and G. Fred Lee. 1977. Algal nutrient availability and limitation in Lake Ontario during IFYGL. Appendices to Part III. Algal nutrient limitation in Lake Ontario during IFTGL. Contract No. R-800537-02. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-046b. 86 p. NTIS No. PB265004.

This study was conducted on the potential significance of nitrogen, phosphorus and micronutrients in limiting planktonic algal growth in Lake Ontario and its major tributaries. Standard algal assay procedures were used. Samples of the open waters of Lake Ontario and Niagara River waters collected during the spring showed phosphorus limitation. By late summer these waters showed both nitrogen and phosphorus limitation. The Genesee and Oswego Rivers showed, in general nitrogen limitation. Samples of Black River waters showed both nitrogen and phosphorus limitation.

This portion of the report includes the appendices for Part III of this study published separately by the Environmental Protection Agency. Appendices include (1) algal bioassays for Lake Ontario water; (2) algal bioassays for Niagara River waters; (3) algal bioassays for Genesee River waters; (4) algal bioassays for Oswego River waters; and (5) algal bioassays for Black River waters.

SOURCE: NTIS PB 265 004

Walbridge, Charles T. 1977. A flow-through testing procedure with duckweed (Lemna minor L.). U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-108. 26 p.

Lemna minor is one of the smallest flowering plants. Because of its floating habit, ease of culture, and small size it is well adapted for laboratory investigations. Procedures for flow-through tests were developed. Testing procedures were developed with this apparatus. By using the techniques described here, the effects of nutrients or toxicants, singly or in combination, can be determined in several concentrations with several replicates of each. Responses which can be measured include changes in growth rate, changes in death rate, changes in timing of division of colonies, color changes, changes in variability, and modification of the flowering response. Emphasis here is on changes in growth rate determined either by daily frond counts or by final frond numbers.

SOURCE: ERL-D

Warren, Charles E., and William J. Liss. 1977. Design and evaluation of laboratory ecological system studies. Grant No. R802286. U.S. Environmental Protection Agency, Duluth, MN. Publication EPA-600/3-77-022. 126 p.

Design and evaluation of laboratory ecological system studies are considered in relation to problems and objectives in environmental toxicology. Ecological systems are defined to be organismic systems together with their level-specific, co-extensive environmental systems and to occur at individual, population, and multispecies levels of biological organization. So that the basis for judgements on the relevance and adequacy of laboratory ecological system studies for solution of problems in environmental toxicology will be clear, a conceptual framework defining with abstract generalizations the nature of biological systems is presented and employed. And a graphical calculus is used to deduce isocline systems, so as to illustrate the importance of empirical evaluation of the capacities, not simply the performances, of laboratory ecological systems. Within the context of apparent toxicological problems and this conceptual framework, the relevance and adequacy of laboratory ecological system studies on toxicant effects and behaviors are evaluated.

SOURCE: ERL-D

Wezernak, C.T. and D.R. Lyzenga. 1977. Satellite remote sensing study of the trans-boundary movement of pollutants. Grant No. R8033671. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication EPA-600/3-77-056. 26 p.

A limited analysis of ERTS (LANDSAT) data of the western basin of Lake Erie and the southern portion of Lake Huron was performed. The objective of the program was to depict the large-scale movement of water masses, and manifested in terms of suspended solids, and to demonstrate the use of ERTS data in large lakes monitoring. ERTS (LANDSAT) data, as recorded on computer compatible tapes, were processed to display surface circulation features, surface suspended solids distribution, surface chlorophyll distribution and secchi disc transparency. The results demonstrate the potential of satellite remote sensing for monitoring of large water bodies.

SOURCE: ERL-D

# JOURNAL ARTICLES

All articles in this section have been authored and published in the open scientific literature by staff members of the Duluth facility and its field stations. Limited quantities of reprints are available for some articles, and those publications identified as an ERL-D reprint can be requested by that number from the Environmental Research Laboratory-Duluth, 6201 Congdon Boulevard, Duluth, MN 55804. All articles not identified as ERL-D reprints can be seen in the professional journals held by most major libraries, particularly those at colleges and universities.

## 1978

Benoit, D.A., and G.W. Holcombe. 1978. Toxic effects of zinc on fathead minnows Pimephales promelas in soft water. J. Fish Biol. 13, 701-708. (Reprint #204).

A fathead minnow life-cycle exposure to various zinc concentrations demonstrated that thermostat sensitive indicators of zinc toxicity were egg adhesiveness and fragility, which were significantly affected at 145 µg Zn $1^{-1}$ and above, but were not affected at 78 µg Zn $1^{-1}$ and below. These effects occurred shortly after the eggs were spawned (during water hardening) and therefore were not related to effects on the parental fish. Hatchability and survival of larvae were significantly reduced, and deformities at hatching were significantly increased at 295 µg $Zn^{-1}$ and above. Acclimated and unacclimated groups of larvae exposed to identical zinc concentrations for 8 weeks after hatch showed only slight differences in sensitivity.

SOURCE: ERL-D Library

Brungs, W.A., and D.I. Mount. 1978. Introduction to a discussion of the use of aquatic toxicity tests for evaluation of the effects of toxic substances, pp. 15-26. In: Estimating the Hazard of Chemical Substances to Aquatic Life, ASTM STP 657, John Cairns, Jr., K.L. Dickson, and A.W. Maki, Eds., American Society for Testing and Materials. (ERL-D Reprint #194).

A variety of classes of aquatic toxicity tests are presented and discussed in relation to their ability to provide useful estimates of the environmental effects of chemicals or discharges. These classes of tests can be judged and compared numerically by several standards: ability to permit extrapolation to meaningful effect; ease and cost of conducting tests; applicability to response to a wide variety of chemicals; availability of documented detailed procedures; ecological

importance and persistence of effect; and scientific and legal defensibility of the procedure. No single class of tests can be expected to be clearly superior to all others, indicating the need for a variety of testing at successive tiers of intensity of study.

SOURCE: ERL-D Library

Brungs, W.A., R.W. Carlson, W.B. Horning II, J.H. McCormick, R.L. Spehar, and J.D. Yount. 1978. Effects of pollution on freshwater fish. J. Water Pollut. Control. Fed. 50(6):1582-1637. (ERL-D Reprint #192).

An extensive review of 338 references on the effects of pollution on freshwater fish covering 1976-1977 is presented. These references cover: Reviews and Symposia, Dissolved Gases, pH, Insecticides, Hercides, Piscicides and Anesthetics, Inorganics, Organics, Chlorine and Wastewater, Pulp and Paper, Radioactive and Physical Factors.

SOURCE: ERL-D Library

Carlson, Anthony, R., and Lawrence J. Herman. 1978. Effect of long-term reduction and diel fluctuation in dissolved oxygen on spawning of black crappie, Pomoxis nigromaculatus. Trans. Am. Fish. Soc. 107(5):742-746. (ERL-D Reprint #198).

Mature black crappies were exposed over winter in the laboratory to constant dissolved oxygen concentrations near 2.5, 4.0, 5.5, and 7.0 mg/liter. Starting on 26 April during a simulated spring-to-summer rise in water temperature, some were continued at the original oxygen concentrations while others were subjected to mean diel fluctuations ranging from 0.8 to 1.9 mg $O_2$/liter above and below the original concentrations. Controls were maintained at concentrations near air saturation. No spawning occurred at the lowest fluctuating treatment of 1.8 to 4.1 mg/liter. This treatment also caused behavioral aberrations as the water temperature reached 20°C. Successful spawning occurred during all other treatments.

SOURCE: ERL-D Library

Carlson, Richard W., and Robert A. Drummond. 1978. Fish cough responses - A method for evaluating quality of treated complex effluents. Water Res. 12:1-6. (ERL-D Reprint #186).

Bluegill sunfish (Lepomis macrochirus) showed increases in cough frequency commensurate with effluent concentration when exposed for 24 hours to different industrial and municipal effluents. Effluents known to be toxic caused steadily increasing cough rates in the fish as effluent concentration approached acutely toxic levels. Bluegills exposed to three different samples of effluent, collected from the same source over an 8-month period, showed decreased levels of cough

rate as the effluent improved in quality. Cough frequency is a rapid and sensitive physiological characteristic for evaluating the quality of industrial and municipal effluents and variation in quality of same-source effluents before discharge into receiving waters.

SOURCE: ERL-D Library

Christensen, G.M., James T. Fiandt, and Barbara A. Poeschl. 1978. Cells, proteins, and certain physical-chemical properties of brook trout (Salvelinus fontinalis) blood. J. Fish Biol. 12:51-60. (ERL-D Reprint #187).

Laboratory brook trout were used to evaluate, refine, or develop biochemical procedures for the analysis of fish blood. Analytical values were obtained for the following blood properties: total and differential leucocytes and erythrocytes; erythrocyte and plasma proteins (by electrophoresis); plasma refractive index; erythrocyte sedimentation rate; erythrocyte osmotic fragility; blood surface tension and density; haemoglobin; and packed cell volume. These blood factors are discussed with reference to fish health and disease and to changes caused by deleterious quantities of water pollutants.

SOURCE: ERL-D Library

Cook, P.M., G.E. Glass, D.R. Marklund, and J.H. Tucker. 1978. Evaluation of cartridge filters for removal of small fibers from drinking water. J. Am. Water Works Assoc. 70(8):459-464. (EL-D Reprint #96).

Prior to completion of new water treatment facilities in Duluth, Minnesota, contamination of the community's water supply by amphibole fibers led to widespread use of individual filtration systems in homes and public buildings. Laboratory tests of several types of cartridge filters, backed by extensive field monitoring of operating filter installations, revealed a number of performance problems and shed light on how to correct them.

SOURCE: ERL-D Library

Cook, P.M., P.L. Smith, and D.G. Wilson. 1978. Amphibole fiber concentration determination for a series of community air samples: Use of x-ray diffraction to supplement electron microscope analysis, pp 107-119. In: Electron Microscopy and X-ray Applications to Environmental and Occupational Health Analysis. P.A. Russel and A.E. Hutchings, Eds., Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan. (ERL-D Reprint #197).

The accurate measurement of annual average mineral fiber concentrations at various air sampling sites provides the best index on non-occupational inhalation exposure to fibers in a community located near an industrial source of airborne amphibole fibers. The transmission electron microscope analysis of enough individual high volume air samples to provide annual

average fiber concentrations is not feasible because of the great time and expense required. X-ray diffraction analysis of air samples collected on membrane filters over periods of several days offers a reliable measurement of amphibole mineral mass concentration. An excellent linear correlation ($r = 0.94$ for $N = 12$) exists between the amphibole mass concentrations (x-ray diffraction) and amphibole fiber concentrations (transmission electron microscope). The correlation equation is used to calculate amphibole fiber concentrations from over 300 x-ray diffraction analyses. The accuracy and precision of both techniques are discussed as well as particle concentration variations influenced by meterology, emission sources, and sampling location.

SOURCE: ERL-D Library

DeFoe, D.L., G.D. Veith, and R.W. Carlson. 1978. Effects of Aroclor$^R$ 1248 and 1260 on the fathead minnow (Pimephales promelas). J. Fish. Res. Board Can. 35:997-1002. (ERL-D Reprint #195).

Fathead minnows were exposed to Aroclor$^R$ 1248 and 1260 in flow-through bioassays to determine the acute (30-d) and chronic (240-d life cycle) effects on the larvae and adults, as well as the bioconcentration of the mixtures of PCBs in the fish. Newly hatched larvae (<8 h old) were the most sensitive; the calculated 30-d LC50 was 4.7 µg/l for Aroclor 1248 and 3.3 µg/l for Aroclor 1260. Reproduction in fathead minnows occurred at concentrations as high as 3 µg/l for Aroclor 1248 and 2.1 µg/l for Aroclor 1260, concentrations that significantly affected larval survival. The 20% reduction in the standing crop in the second-generation fish at concentrations as low as 0.4 µg/l was due to the death of the larvae soon after hatching. The bioconcentration factor for PCBs was independent of the PCB concentration in the water; in adult females at 25°C it was $1.2 \times 10^5$ for Aroclor 1248 and $2.7 \times 10^5$ for Aroclor 1260. Females accumulated about twice as much PCBs as the males because of the greater amount of lipid in the female. Exposed fish placed in untreated Lake Superior water eliminated <18% of the body burden after 60 d.

SOURCE: ERL-D Library

Dolan, D.M., V.J. Bierman, Jr., M.H. Dipert, and R.D. Geist. 1978. Statistical analysis of the spatial and temporal variability of the ratio chlorophyll A to phytoplankton cell volume in Saginaw Bay, Lake Huron. J. Great Lakes Res., Internat. Assoc. Great Lakes Res. 4(1):75-83.

Chlorophyll *a* has traditionally been used as an indicator of phytoplankton concentration in natural waters. This parameter has also been widely used by phytoplankton modelers for the purpose of comparing model output with field data. Examination of 1974 field data from Saginaw Bay indicated that chlorophyll *a* concentrations were inconsistent with phytoplankton cell volume concentrations. Statistical procedures were employed to determine the significance and source of the observed variability in the ratio of chlorophyll *a* to cell volume concentrations.

The procedures employed included t-tests, analysis of variance and polynomial regression. The hypothesis that the natural log of the ratio of chlorophyll a to cell volume was constant in time was tested on six different sampling station groupings representing various spatial divisions of Saginaw Bay. In all cases, this ratio was decreased when only data from the outer portion of Saginaw Bay were used. Greater than 60% of the variability of the ratio can be removed by using a linear correlation of the natural log chlorophyll a cell volume ratio with the fraction of diatom cell volume.

SOURCE: LLRS

Dolan, David M., and Victor J. Bierman, Jr. 1978. Comment on "A model for total phosphorus in Saginaw Bay". J. Great Lakes Res., Internat. Assoc. Great Lakes Res. 4(1):110-113.

The subject paper (Canale and Squire 1976) presents the results of the application of a steady-state mass balance model to chloride and total phosphorus data for Saginaw Bay in 1974. Richardson (1974, 1976) has modeled chloride in Saginaw Bay on both a steady-state and a time variable basis. In this work, the steady-state model was shown to be inadequate for this system, except during stable periods in summer and fall. Since most of the loading of pollutants to the bay does not occur at these times, the time variable model was developed. The purpose of this comment is to compare similar aspects of these projects and to contrast the steady-state and time variable approaches with respect to their ability to simulate observed phenomena and the utility of their results.

SOURCE: LLRS

Eaton, J.G., J.M. McKim and G.W. Holcombe. 1978. Metal toxicity to embryos and larvae of seven freshwater fish species -- 1. Cadmium. Bull. Environ. Contam. Toxicol. 19(1):95-103. (ERL-D Reprint #183).

The embryos and larvae of seven freshwater fish were exposed to low concentrations of cadmium in soft water. All species were killed or their growth retarded by concentrations ranging from about 4 to 12 µg Cd/liter. The larvae were consistently more sensitive than the embryos. The agreement between these results and those from life-cycle chronic toxicity studies indicates that embryo and larval exposures will give reliable estimates of the chronic toxicity of cadmium to additional fish species. A 60-day exposure period appears to be appropriate for determining larval sensitivity to cadmium.

SOURCE: ERL-D Library

Halligan, Barbara J., and John G. Eaton. 1978. Survival and reproduction of Gammarus lacustris and G. pseudolimnaeus under two experimental conditions. Prog. Fish-Cult. 40(2):59-62. (ERL-D Reprint #191).

Life-cycle tests on the survival and reproduction of the amphipods Gammarus lacustris and G. pseudolimnaeus were conducted under two nontoxicant experimental conditions: with several amphipods per tank and with individual pairs per tank. Juvenile and adult survival of the two species was similar with several amphipods per tank, but was higher for G. lacustris among the reproducing individual pairs. In the multiple-animal tanks G. lacustris females had larger broods than did G. pseudolimnaeus females and both species produced more young per females and more broods per female than in the tanks with individual pairs. Our results indicate that these amphipods may be reared more successfully with several animals per tank than with only two. Of the two species, G. lacustris may be preferred for use in chronic toxicity tests because of its greater fecundity, larger size and wider distribution.

SOURCE: ERL-D Library

Helmy, M.M., A.E. Lemke, P.G. Jacob, and B.L. Oostdam. 1978. Effects of some trace elements on the blood of Kuwait mullets, Liza macrolepis (Smith). J. Exp. Mar. Biol. Ecol. 34:151-161.

Haemopathological changes attributed to heavy metal poisoning were observed in blood smears of Liza macrolepis (Smith) taken after exposures of 96 h to graded doses (mg/l) of copper (0.11-1.80), lead (1.15-18.36), and mercury 0.04-0.59), in a flow-through marine bioassay system. In general, changes in leucocytic profile appear to be correlated with pathological changes caused by increasing copper and mercury concentrations. By contrast, blood samples of mullets exposed to lead, showed significant polychromasia and +1 anisocytosis regardless of concentrations. The RBC count, haemoglobin content, and haematocrit percentages were less valuable in diagnosis of copper and mercury effects.

These manifestations of poisoning by trace elements bear a resemblance to the pathological changes that have been shown clinically and experimentally in mammals. Consequently, blood measurements on marine organisms may be diagnostic of undesirably high levels of copper and mercury, and so may constitute useful indicators of marine pollution.

SOURCE: ERL-D Library

Hermanutz, Roger O. 1978. Endrin and malathion toxicity to flagfish (Jordanella floridae). Arch. Environ. Contam. Toxicol. 7:159-168. (ERL-D Reprint #188).

Endrin and malathion effects on survival, growth, and reproduction of flagfish were determined in a flow-through system. Endrin chronic effects on first-generation growth and reproduction occurred only at 0.3 µg/l, the highest concentration tested. The mean endrin residues in the first-generation fish at 65 days were about 15,000 times the water concentration in all concentrations tested. Malathion concentrations of 31.5 µg/l and 24.7 µg/l, the highest concentrations tested,

had detrimental effects on first-generation survival. During the same period malathion concentrations as low as 10.9 µg/l significantly affected growth. Neither insecticide, at the concentrations tested, had any detectable effects on the second generation during a 30-day exposure period.

SOURCE: ERL-D Library

Jarvinen, Alfred W., and Robert M. Tyo. 1978. Toxicity to fathead minnows of endrin in food and water. Arch. Environ. Contam. Toxicol. 7:409-421. (ERL-D Reprint #202).

Fathead minnows (Pimephales promelas) were exposed during a partial chronic toxicity study to endrin concentrations in the water or food, or both, for 300 days encompassing reproduction. Tissue residues were analysed at preset intervals for first-generation fish, and were also determined for embryos, larvae at hatch and 30-day progeny. Gas-chromatographic and liquid-scintillation techniques were used to monitor the contribution of endrin from each source. The food was clams that had accumulated 14C-endrin when exposed to an endrin water concentration similar to that to which the fish was exposed.

Higher endrin tissue residues were accumulated from the water than from food. Maximum concentration factors were 0.8 from the food and 13,000 from the water. Residues contributed by endrin in the food were additive to those from the water at all life stages. Endrin in the food (0.63 ppm) significantly reduced survival of the fathead minnows, and fish exposed to both endrin sources had lower survival than those exposed to either sources alone. Endrin residues in embryos and larvae were highest and larval survival lowest for progeny of adults exposed to endrin in both food and water. Survival of 30-day progeny was significanly reduced at all test exposures (0.63 ppm in the food, water exposures at 0.14 and 0.25 ppb, and all combinations of food and water exposure).

SOURCE: ERL-D Library

Kuehl, Douglas W., and Edward N. Leonard. 1978. Isolation of xenobiotic chemicals from tissue samples by gel permeation chromatography. Anal. Chem. 50:182-185. (ERL-D Reprint #181)

A gel permeation technique has been developed for tissue sample cleanup for gas-liquid chromatographic-mass spectrometric analysis of low molecular weight polar organic (LMWO) compounds. The technique involves a two step procedure to first separate the bulk lipid material from LMWOs and then fractionate LMWOs by both polarity and molecular size.

SOURCE: ERL-D Library

Kuehl, Douglas W., Gilman D. Veith, and Edward H. Leonard. 1978. Brominated compounds found in waste-treatment effluents and their capacity to bioaccumulate. Pages 175-192. In: Water Chlorination, Environmental Impact and Health Effects, Volume 2. R.L. Jolley (ed). Ann Arbor Science Publishers, Inc., Ann Arbor, MI. (ERL-D Reprint #190)

Gas chromatography-mass spectrometry was used to analyze residues in fathead minnows (Pimephales promelas) which were exposed to nondisinfected and bromine chloride disinfected wastewater effluent. A series of brominated organic chemicals was identified in the fish exposed to the bromine chloride disinfected effluent but were not detected in fish exposed to the non-disinfected wastewater. Two mechanisms for the presence of these residues include the aqueous bromination of precursors followed by bioaccumulation of the products, and the bromination of precursors by the fish.

SOURCE: ERL-D Library

Maier, Walter J., and Wayland R. Swain. 1978. Lake Superior organic carbon budget. Water Res. 12:403-412.

The organic carbon concentration of Lake Superior is discussed in terms of a simple mathematical model that treats the lake as a well mixed basin. Major sources, outflows, and biochemically mediated removal of organic carbon are analyzed in the time frame of yearly average values. Data on organic carbon concentrations of watershed drainage, rainfall, anthropogenic inflows and contributions from photosynthetic production are analyzed as are the removal of organics by biochemical oxidation and sedimentation. The long range projected effects of the major sources and sinks on the yearly average organic carbon concentration of the lake are described.

SOURCE: LLRS

Maier, W.J., and W.R. Swain. 1978. Organic carbon - A nonspecific water quality indicator for Lake Superior. Water Res. 12:523-529.

Organic matter is ubiquitous in surface waters and its presence is generally recognized as being detrimental to water quality. Historically, biochemical oxygen demand (BOD) has been used to assess the effects, and indirectly the concentration, of organic matter in water. However, BOD measurements are not adequate for characterization of high quality natural waters. Measurements of organic carbon by paper is the first part of a study of the distribution of organic carbon in Lake Superior Basin waters. Temporal and spatial distribution of organic carbon in open waters and in the vicinity of pollution inflows are described. Base line concentration levels have been established, and the use of organic carbon measurements as an overall indicator of water quality is discussed.

SOURCE: LLRS

McCormick, J. Howard. 1978. Effects of temperature on hatching success and survival of larvae in the white bass. Prog. Fish-Cult. 40(4):133-137. (ERL-D Reprint #203)

Temperature effects on the hatching success of eggs of the white bass (Morone chrysops) were determined by exposing sample lots of recently fertilized eggs to 10 constant temperatures, 6 through 30°C. Different lots of eggs were exposed to test temperatures before gastrulation, and after closure of the blastopore in the embryo. The percentages of normal larvae hatched were not significantly ($P > 0.05$) impaired in eggs exposed before gastrulation at temperatures from 18 through 26°C, nor in those first exposed after closure of the blastopore at temperatures from 14 through 26°C. Eggs incubated at 14°C hatched 4.5 days after fertilization, and those incubated at 26°C required only 1 day. The 24-h TL50 for white bass larvae exposed within 24-h of hatching and acclimated to 14, 18, 20, and 26°C was between 30 and 32°C, and was not altered by the acclimation temperatures tested.

SOURCE: ERL-D Library

McKim, J.M., J.G. Eaton, and G.W. Holcombe. 1978. Metal toxicity to embryos and larvae of eight species of freshwater fish -- II: Copper. Bull. Environ. Contam. Toxicol. 19:608-616. (ERL-D Reprint #189)

Fish larvae and early juveniles of all species tested (brook trout, rainbow trout, brown trout, lake trout, northern pike, white sucker, herring, and smallmouth bass) were more sensitive to copper than the embryos. Embryo survival was affected only at the higher concentrations tested, for all species except the rainbow trout. The concentrations of copper that caused significant effects on the larval standing crop were similar for all species (31.7-43.5 µg Cu/l) except the northern pike, which seemed to be considerably more resistant (104.1 µg Cu/l). Copper concentrations shown to have no significant effects on the early developmental stages of these species are considered close estimates of the copper concentrations that would have no measurable adverse effects during a complete life cycle toxicity test under similar test conditions.

SOURCE: ERL-D Library

Poldoski, J.W., and G.E. Glass. 1978. Anodic stripping voltammetry at a mercury film electrode: Baseline concentrations of calcium, lead, and copper in selected natural waters. Anal. Chim. Acta 101(1978):79-88. (ERL-D Reprint #199)

A simple, rapid and expensive anodic stripping voltammetric method with a mercury thin film electrode is reported for the establishment of baseline concentrations of cadmium, lead, and copper in natural waters. The procedure for routine surface preparation of wax-impregnated graphite mercury film electrodes requires about 30 min. Concentrations

in the 0.006-6 g l-1 range are determined by linear d.c. voltage sweeps; the total time for a plating and stripping cycle is 6 minutes or less. The need for pressure-digesting samples for copper determinations is demonstrated. The a.s.v. results correlate well with corresponding analyses performed by graphite-furnace atomic absorption spectrometry.

SOURCE: ERL-D Library

Poldoski, J.E., E.N. Leonard, J.T. Fiandt, L.E. Anderson, G.F. Olson, and G.E. Glass. 1978. Factors in the determination of selected trace elements in near-shore U.S. waters of Lakes Superior and Huron. Internat. Assoc. Great Lakes Res. 4(2):206-215. (ERL-D Reprint #205)

Determination of total As, Cr, Cu, Fe, Mn, and Pb in acidified unfiltered water samples from 48 stations representing the nearshore U.S. waters of Lake Superior, Lake Huron, and selected incoming streams gave overall mean concentrations and standard deviations (µg/l) of 1.0 $\pm$ 0.7, 0.9 $\pm$ 1.8, 2.0 $\pm$ 1.8, 236 $\pm$ 819, 14 $\pm$ 34, and 0.7 $\pm$ 0.8, respectively, using flameless atomic absorption analytical methods. Total concentrations of Ni and Hg were usually less than the instrumental detection limits (µg/l) of 0.8 and 0.02, respectively. Small losses of Hg, As, and Cr from solutions are possible in addition to a molecular spectral interference in the determination of As using the graphite furnace method. River waters usually were only slightly higher in total element concentrations than lake waters, except for Fe and Mn. Nearshore waters of both lakes were very similar in elemental composition.

SOURCE: ERL-D Library

Salmela, Jack A., and Richard L. Anderson. 1978. Thermal shock effects on larvae of caddis fly Brachycentrus americanus. J. Minn. Acad. Sci. 44(3):25-28. (ERL-D Reprint #200)

Wild-collected Brachycentrus americanus larvae were subjected to thermal shocks of 30-minute and 60-minute duration in June, September, and December of 1976. Temperatures at collection were 14.7, 10.4, and 1.2°C, respectively. The TL50s for both 30-minute and 60-minute shock durations ranged from 33.3°C to 34.0°C for each month, except for a 30-minute exposure in September, which had a TL50 of 34.6°C. Larvae from a December exposure were held for 16 days to observe postexposure behavior. Feeding was reduced 50 percent among specimens exposed to temperatures 1.2°C below the 30-minute TL50 and 3.6°C below the 60-minute TL50.

SOURCE: ERL-D Library

Spehar, Robert L., Richard L. Anderson, and James T. Fiandt. 1978. Toxicity and bioaccumulation of cadmium and lead in aquatic invertebrates. Environ. Pollut. 15:195-208. (ERL-D Reprint #185)

Cadmium toxicity and lead toxicity to four species of insects (Pteronarcys dorsata, Hydropsyche betteni, Brachycentrus sp. and Ephemerella sp.), one snail (Physa integra) and one amphipod (Gammarus pseudolimnaeus) were determined during 28-day exposures. The 28-day LC50 values for cadmium-exposed snails and lead-exposed amphipods were eleven and four times lower than the 7- and 4-day (96-hr) values for these metals, respectively. Lowest effect concentrations obtained after 28-days for cadmium-exposed mayflies (Ephemerella sp.) and snails and lead-exposed amphipods were similar to those affecting fish exposed over their complete life cycle in water of similar quality. Lethal threshold concentrations were not observed for species exposed to either metal, indicating that possible effects could occur at lower concentrations during longer exposure periods. Cadmium and lead concentrations in the animals tested generally increased with increasing water concentrations and were up to 30,000 and 9,000 times greater than corresponding metal concentrations in the water.

SOURCE: ERL-D Library

Spehar, Robert L., Edward N. Leonard, and David L. DeFoe. 1978. Chronic effects of cadmium and zinc mixtures on flagfish (Jordanella floridae). Trans. Am. Fish. Soc. 107(2):354-360. (ERL-D Reprint #193)

Flagfish were exposed to cadmium and zinc as individual metals and as mixtures (4.8-8.5 µg Cd/liter and 73.4-139 µg Zn/liter) though one complete life cycle in Lake Superior water (45 mg/liter total hardness). Cadmium and zinc did not act additively at sublethal concentrations when combined as mixtures; however, a joint action of the toxicants was indicated. Effects on survival showed that the toxicity of cadmium and zinc mixtures was little if any greater than the toxicity of zinc alone. Mechanisms of zinc toxicity in this test was similar to those in previous chronic tests of individual metals, indicating that the presence of cadmium did not influence the mode of action of zinc. Comparisons between metal residues in fish exposed to each individual metal or to the metal mixtures showed that the uptake of one metal was not influenced by the presence of the other.

SOURCE: ERL-D Library

Swain, Wayland R. 1978. The computerized ecosystem. Natural history, August/September 1978:95-96.

A generalized discussion of mathematical simulation used on the Great Lakes is presented for the layman. Illustrations of model utilization are presented and the complexities of ecosystem simulation are noted.

SOURCE: LLRS

# 1977

Andrew, R.W., K.E. Biesinger and G.E. Glass. 1977. Effects of inorganic complexing on the toxicity of copper to Daphnia magna. Water Res. 11: 309-315. (ERL-D Reprint #153)

Effects of carbonate-bicarbonate, orthophosphate and pyrophosphate on the toxicity of copper (II) to Daphnia magna were studied at constant pH and total hardness. Mortality rates and reciprocal survival times were directly correlated with cupric ($Cu^{2+}$) and copper hydroxyl [Cu(OH)n] ion activities as determined by equilibrium calculations. Toxicity was negatively related to activities of soluble copper carbonate ($CuCO_3$) and other complexes, and was found to be independent of dissolved copper or total copper concentrations.

SOURCE: ERL-D Library

Benoit, Duane A., and Richard W. Carlson. 1977. Spawning success of fathead minnows on selected artificial substrates. Prog. Fish-Cult. 39(2): 67-69. (ERL-D Reprint #158).

Spawning success of fathead minnows (Pimephales promelas) on six different substrates was tested and evaluated. Egg adhesiveness was equally good on cement-asbestos tile and sand-coated stainless steel substrates, but was poor on unaltered stainless steel, shot-peened stainless steal, stainless steel screen, and glass substrates. Viability and number of eggs spawned were not significantly different for any of the substrates tested.

SOURCE: ERL-D Library

Brungs, William A. 1977. Uses of environmental maps in determining areas of noncompliance. In: Workshop on Environmental Mapping of the Great Lakes, Proceedings of a Symposium, Windsor, Ontario, November 8-10, 1976, (D.R. Rosenberger, and A. Robertson, eds.). pp 9-13.

A procedure for determining acceptable areas of non-compliance (mixing zones) around point source discharges is described that is based on the assignment of relative ecological values to different areas using environmental maps.

SOURCE: ERL-D Library

Brungs, William A. 1977. General considerations concerning the toxicity to aquatic life of chlorinated condenser effluent. In: Biofouling Control

Procedures; Technology and Ecological Effects, L.D. Jensen, editor, pp 109-113, Marcel Dekker, Inc., NY, NY.

Most chlorine toxicity studies have been conducted under conditions of constant exposure, rather than under intermittent chlorination conditions. The recent emphasis to generate more appropriate data under power plant operational modes will result in a more comprehensive and appropriate basis for criteria development. In the interim, several considerations need to be discussed in detail: (1) toxicity is time, concentration, water quality, and species related; (2) disequilibrium usually results in mortality; (3) various physical, biological, and chemical factors may influence observed effects at plants during chlorination; and (4) a representative research program involves variable exposure times, exposure concentrations, water quality, and both fish and invertebrate species.

SOURCE: ERL-D Library

Brungs, W.A., J.H. McCormick, T.W. Neiheisel, R.L. Spehar, C.E. Stephan, and G.N. Stokes. 1977. Effects of pollution on freshwater fish. J. Water Pollut. Control Fed. 49(6):1425-1439. (ERL-D Reprint #164)

This literature review covered 464 scientific papers with categories on Reviews and Symposia, Dissolved Gases, Salinity, pH, Insecticides, Herbicides, Piscicides, Inorganics, Organics, Domestic Pollutants, Radioactive Pollutants, and Other Pollutants. The review includes a tabulation of numerical results of toxicity testing.

SOURCE: ERL-D Library

Christensen, Glenn M., James T. Fiandt, and Duane A. Benoit. 1977. Estimation of live fish weight by photography. Prog. Fish-Cult. 39(1): 41-42. (ERL-D Reprint #155).

Approximate weights of fish were calculated from length and width measurements of their photographic images. In the calculations the formula $Wt = KLW^2$ was employed where Wt = weight (g); K = proportionality factor, derived from a subsample of the population under study; L = length (cm); and W = width (cm). When tested against true weights, the derived weights had a mean error of $\pm 8.6\%$.

SOURCE: ERL-D Library

Christensen, G., E. Hunt, and J. Fiandt. 1977. The effect of methylmercuric chloride, cadmium chloride and lead nitrate on six biochemical factors of the brook trout (Salvelinus fontinalis). Toxicol. Appl. Pharmacol. 42:523-530. (ERL-D Reprint #182)

Brook trout were exposed to experimental water concentrations of methylmercuric chloride from 0.01 to 2.98 µg of Hg/liter, to cadmium chloride from 0.06 to 6.35 µg of Cd/liter, and of lead nitrate from 0.90 to 474 µg Pb/liter. Exposures for 2- and 8-week periods. Fish weight and length, hemoglobin, and blood plasma sodium, chloride, glucose, glutamic oxalacetic transaminase and lactic dehydrogenase were measured. The following observed changes were statistically significant: increases in plasma sodium and chloride and decreases in hemoglobin and glutamic oxalacetic transaminase activity caused by lead: increases in plasma chloride and lactic dehydrogenase activity and a decrease in plasma glucose caused by cadmium; and increases in hemoglobin and plasma sodium and chloride caused by methylmercury. Comparisons were made between these biochemical findings and published data from bioassay and tissue-residue studies regarding the determination of threshold indices of toxicity.

SOURCE: ERL-D Library

Collette, B.B., M.A. Ali, K.E.F. Hokanson, M. Nagiec, S.A. Smirnov, J.E. Thorpe, A.H. Weatherley, and J. Willemsen. 1977. Biology of the percids. J. Fish. Res. Board Can. 34:1890-1899. (ERL-D Reprint #178)

The structure, origin and spread of the family Percidae are reviewed briefly, and its characteristics compared with those of other families of freshwater fishes. It is suggested that the percids, essentially riverine, have been restricted in their success in North America by the presence of the Centrachidae. Percids are defined as temperate mesothermal fish, and this physiological characteristic together with osmoregulatory capacity and swimming performance is shown to limit the ranges of the perches. The degree of development of the tapetum lucidum in Stizostedion spp. and of the lateral line in all percids is related to differences in pattern of development. Feeding behavior is also reviewed.

SOURCE: ERL-D Library

DeFoe, David L. 1977. Temperature safety device for aquatic laboratory systems. Prog. Fish-Cult. 39(3):131. (ERL-D Reprint #167)

The temperature safety device described here will protect aquatic organisms in experiments or in rearing and holding facilities by stopping water flow when set temperatures are exceeded. The device consists of switches constructed from aquarium heaters that are activated by excessively high and low temperatures.

SOURCE: ERL-D Library

Drummond, R.A. 1977. Disposable electrode chamber for measuring opercular movements of fathead minnows. Prog. Fish-Cult. 39(2):94. (ERL-D Reprint #159).

A simple, disposable electrode chamber to measure the opercular movements of fathead minnows is described.

SOURCE: ERL-D Library

Glass, Gary E. 1977. Identification and distribution of inorganic components in water; What to measure? Ann. N.Y. Acad. Sci. 298:31-46. (ERL-D Reprint #175)

The chemical forms of inorganic components in water are widely varied and range from simple aqua complexes in solution to complicated silicate minerals in suspension. A variety of techniques are used to determine the total quantities of components in a particular aqueous environment by summation of the individual chemical species present. The biological response of organisms is not in general related to the total concentration of the components present but only to some fraction of the total, i.e., those chemical forms which interact most strongly with the biota and are absorbed. Chemical equilibria calculations are used to provide an estimate of the distribution of metal and ligand species in Lake Superior water and may be used to define important parameters of the system for study and measurement. Comparisons of calculated chemical species distribution with the direct toxic responses of aquatic organisms show that only a small fraction of total copper is toxic while much larger fractions of the total are toxic for cadmium and mercury. When metals are bound in silicate minerals they do not exhibit direct toxic effects of fish but their internal organs do show metal uptake. Some inorganic components of Lake Superior have been identified and show concentrations in drinking water for lead, 0.1-150 µg/l; suspended solids, 0.5-39 mg/l; inorganic fibers, up to one billion cummingtonitegrunerite (amosite) and fiberglass, depending upon the time and place of sampling.

SOURCE: ERL-D Library

Glass, G.E., W.M.I. Strachan, W.A. Willford, F.A.I. Armstrong, K.L.E. Kaiser and A. Lutz. 1977. Organic Contaminants. In: The Waters of Lake Huron and Lake Superior, Volume III (Part B), Chapter 6.4, pp 417-429; 499-502. Report to the International Joint Commission by the Upper Lakes Reference Group. Windsor, Ontario. (ERL-D Reprint #173)

6.4 Organic contaminants in Lake Superior. Review of potential problems. Specific contaminants; Polychlorinated Biphenyls, DDT and its metabolites; Aldrin plus Dieldrin; hexachlorobenzene, Lindane; chlordane, methoxychlor; polynuclear aromatic hydrocarbons; chlorobenzene compounds; phenols; phthalate esters; chloronorbornene; octachlorostyrene; methylbenzothiopene; biphenyl; Endosulfan; cyanide; heptachlor epoxide; other organic constituents. Discussion: Persistent organic contaminants; taste and odour compounds. Conclusions.

SOURCE: ERL-D Library

Glass, G.E., W.M.I. Strachan, W.A. Willford, F.A.I. Armstrong, K.L.E. Kaiser and A. Lutz. 1977. Organic Contaminants. In: The Waters of Lake Huron and Lake Superior, Volume II (Part B), Lake Huron, Georgian Bay, and the North Channel, Chapter 6.4 pp. 577-590; 667-670. Report to the International Joint Commission by the Upper Lakes Reference Group. (ERL-D Reprint #174)

6.4 Organic contaminants in Lake Huron. Review of potential problems. Specific contaminants; Polychlorinated biphenyls, DDT and its metabolites; Aldrin plus Dieldrin; hexachlorobenzene, Lindane; chlordane, methoxychlor polynuclear aromatic hydrocarbons; chlorobenzene compounds; phenols; phthalate esters; chloronorbornene; octachlorostyrene; methylbenzothiopene; biphenyl; Endosulfan; cyanide; heptachlor epoxide; other organic constituents. Discussion: Persistent organic contaminants; taste and odour compounds. Conclusions.

SOURCE: ERL-D Library

Hokanson, Kenneth E.F. 1977. Temperature requirements of some percids and adaptations to the seasonal temperature cycle. J. Fish. Res. Board Can. 34(10):1524-1550. (ERL-D Reprint #172).

Temperature requirements are reviewed for three North American percids (walleye, Stizostedion vitreum vitreum; sauger, S. canadense; and yellow perch, Perca flavescens), three Eurasian percids (perch, P. fluviatilis; Pikeperch, S. lucioperca; and ruffle, Gymnocephalus cernua), and nine cohabitant fish species for comparison. Whole-organism responses are described for each species--primarily concerning reproduction, growth, survival, and activity. The percids are classified as temperature mesotherms and they are arranged in order of their thermal requirements as follows; pikeperch perches and ruffle sauger walleye. Perca and Stizostedion sp. are annual spawners with synchronous oocyte growth during fall through winter, culminating in spring spawning. Maturation occurs below 12°C. Spawning occurs from late February through early July at 2-26°C over their geographic ranges. Oocyte growth of ruffe is asynchronous, accelerated by warm temperatures; batch spawning occurs over a prolonged period, from mid-April through July at 11-18°C. Physiological optima range from 22°C for sauger and walleye to 25°C for perch and 27°C for pikeperch. The ultimate upper incipient lethal temperatures of percids range from 29 to 35°C, depending on species and experimental conditions.

Percid life phases are uniquely adapted to the seasonal temperature cycle of a temperate climate. Mechanisms of adaptation to the seasonal temperature cycle are discussed. No uniform mechanism of population regulation or resiliency is apparent for different acclimatization conditions. Therefore, management regulations for a given species should not be universally applied throughout its geographic range.

SOURCE: ERL-D Library

Hokanson, K.E.F., C.F. Kleiner, and T.W. Thorslund. 1977. Effects of constant temperatures and diel temperature fluctuations on specific growth and mortality rates and yield of juvenile rainbow trout, Salmo gairdneri. J. Fish. Res. Board Can. 34(5):639-648. (ERL-D Reprint #157)

Specific growth and mortality rates of juvenile rainbow trout (Salmo gairdneri) were determined for 50 days at seven constant temperatures between 8 and 22°C and six diel temperature fluctuations (sine curve of amplitude ±3.8°C about mean temperatures from 12 to 22°C). For constant temperature treatments the maximum specific growth rate of trout fed excess rations was 5.12%/day at 17.2°C. An average specific mortality rate of 0.35%/day was observed at the optimum temperature and lower. At temperatures in excess of the growth optimum, mortality rates were significantly higher during the first 20 days of this experiment than the last 30 days. The highest constant temperature at which specific growth and mortality rates became equal (initial biomass remained constant over 40 days) was 23°C. The upper incipient lethal temperature was 25.6°C for trout acclimated to 16°C. A yield model was developed to describe the effects of temperature on the living biomass over time and to facilitate comparison of treatment responses. When yield was plotted against mean temperature, the curve of response to fluctuating temperatures was shifted horizontally an average 1.5°C towards colder temperatures than the curve of response to constant temperature treatments. This response pattern to fluctuating treatments indicates that rainbow trout do not respond to mean temperature, but they acclimate to some value between the mean and maximum daily temperatures. These data are discussed in relation to establishment of criteria for summer maximum temperatures for fish.

SOURCE: ERL-D Library

Jarvinen, A.W., M.J. Hoffman, and T.W. Thorslund. 1977. Long-term effects of DDT food and water exposure to fathead minnows (Pimephales promelas). J. Fish. Res. Board Can. 34:2089-2103. (ERL-D Reprint #179)

Fathead minnows (Pimephales promelas) were exposed during a partial chronic toxicity test to two DDT concentrations in the water, one in the diet, and combinations of water and diet for 266 days through a reproductive period of their life cycle. Tissue residue analyses were performed at preset intervals throughout the exposure and also on embryos, larvae at hatch, and 30- and 60-day progeny. The contribution of DDT from each source was monitored with gas chromatography and liquid-scintillation techniques. The fish were fed a diet of clams that had accumulated $^{14}$C-DDT when exposed at a DDT water concentration similar to that in the high fish exposure. Higher total DDT tissue residues were accumulated from the water than diet. Residues contributed by dietary DDT were additive to those from the water. Mean concentration factors were 1.2 for diet and 100,000 for the water. Fish exposed to DDT in both water and diet had higher mortality rates than those exposed to only one or the other of these sources. DDT in the diet significantly reduced the probability of survival of the test fish

(P = 0.025). Estimated maximum acceptable toxicant concentrations for DDT are 0.9 µg/l for fish exposed to DDT in the water only and 0.4 µg/l for fish exposed to DDT in both water and diet. Embryo residue levels and larval mortality rates were about twice as great for those from parent fish that had been exposed to DDT in both the water and diet as for those from parent fish exposed to only DDT in the water.

SOURCE: ERL-D Library

Jones, B.R., K.E.F. Hokanson, and J.H. McCormick. 1977. Winter temperature requirements for maturation and spawning of yellow perch Perca flavescens (Mitchill). In: Towards a Plan of Actions for Mankind, Volume 3, Biological Balance and Thermal Modifications. Proceedings of the World Conference. (M. Marios (ed.)). pp 189-192. Permagon Press, New York, NY. (Reprint #184)

Groups of sexually mature yellow perch were held during the winter at constant temperatures of 4 and 6°C for 123, 143, 164, 185, and 213 days, and of 8 and 10°C for 157, 201, and 241 days. The winter temperatures were raised to 20°C at a rate of 2°C per week at the end of each duration. The greatest reproductive success occurred in the group exposed to 4°C for 185 days at a median spawning temperature of 12°C. High spawning temperatures were associated with shorter durations and lower reproductive success. Reproductive success was lower at maturation temperatures above 4°C and at durations departing from 185 days.

SOURCE: ERL-D Library

Koonce, J.F., T.B. Bagenal, R.F. Carline, K.E.F. Hokanson, and M. Niagiec. 1977. Factors influencing year-class strength of percids: A summary and a model of temperature effects. J. Fish. Res. Board Can. 34:1900-1909. (ERL-D Reprint #177)

Factors regulating year-class strength in the percid genera Stizostedion and Perca are summarized. Some index of water temperature regime correlates significantly with year-class strength of percids in many water bodies. Moderate synchrony of year-class strength is noted for walleye (Stizostedion vitreum vitreum) in several lakes in North America. A probablistic model is proposed to explain the basis of temperature dependence of year-class strength in percids, but tests of the model using Lake Erie data indicated that observed correlations between temperature and year-class strength of yellow perch (Perca flavescens) and walleye may not be the result of direct effects of the temperature regime on survivorship of early life-history phases.

SOURCE: ERL-D Library

Kuehl, D.W. 1977. Identification of trace contaminants in environmental samples by selected ion summation analysis of gas chromatographic-mass spectral data. Anal. Chem. 49(3):521-522. (ERL-D Reprint #154)

A data processing technique has been developed to rapidly and efficiently examine gas chromatographic mass spectral (GC/MS) data for specific compounds in a sample. The technique has been termed "Selected Ion Summation Analysis" (SIS Analysis) and is defined as an ion-intensity profile generated at the termination of a repetitive scanning GC/MS analysis by summing the intensities of selected masses and reporting the summation vs spectrum number if and only if all specified masses are present. SIS has been shown to be an excellent technique for the analysis of a wide variety of environmental pollutants.

SOURCE: ERL-D Library

Lemke, A.E. 1977. Optimum temperature for growth of juvenile bluegills. Prog. Fish-Cult. 39(2):55-57. (ERL-D Reprint #160).

Juvenile bluegills, Lepomis macrochirus (initial weight, 1.8-8.0 g), were individually marked and fed to excess during a 30-day constant temperature test; day length was 16 h. Fish were tested at temperature intervals of 2° from 20 to 36°C. The highest specific growth rate occurred at 30°C (2.35%/day); however, growth rates of only the groups held at 20 and 36°C were statistically different from the rate for the growth held at 30°C.

SOURCE: ERL-D Library

McCormick, J. Howard, Bernard R. Jones, and Kenneth E.F. Hokanson. 1977. White sucker (Catostomus commersoni) embryo development, and early growth and survival at different temperatures. J. Fish. Res. Board Can. 34(7): 1019-1025. (ERL-D Reprint #163)

White sucker (Catostomus commersoni) were exposed from fertilization through hatching to seven constant temperatures from 6.2 through 24.1°C. High percentages of apparently normal larvae hatched at temperatures from 9.0 through 17.2 °C. Maximum percent hatch occurred at 15.2°C, while only a few normal larvae were produced at 6.2°C, and none at 24.1°C.

Growth rates increased from near zero at 10.0°C to a maximum at 26.9°C. At 29.7°C growth fell below the maximum ($P<0.05$), and the incidence of spinal deformities was high. Death rates were uniformly low from 15.7 to 26.9°C and were significantly higher at 10.0 and 29.7°C ($P<0.05$). The rate of net biomass gain for test groups was maximum at 26.9°C. Net rates of biomass gain declined progressively with temperatures below 26.9°C until by 10.0°C the rate of population growth became less than the rate of weight loss through deaths within the population. The

temperature producing maximum hatching success, 15°C, was nearly 12°C lower than that providing for maximum growth and net biomass gain.

Upper thermal 1-, 2-, and 7-day TL50 values for both newly hatched and swim-up larvae, when acclimated to 9 and 10°C, were between 28 and 29°C. When acclimated to 15 and 21°C, they were between 30 and 32°C.

Lower 1-day TL50 temperature values for both groups of larvae acclimated to 21°C were near 3°C (<2.9), TL50 values were approximately 0.5°C higher, and 7-day values were 4.8°C for newly hatched larvae and 6.1°C for swim-up larvae.

SOURCE: ERL-D Library

McKim, James M. 1977. Evaluation of tests with early life stages of fish for predicting long-term toxicity. J. Fish. Res. Board Can. 34(8):1148-1154. (ERL-D Reprint #166)

Partial and complete life-cycle toxicity tests with fish, involving all developmental stages, have been used extensively in the establishment of water-quality criteria for aquatic life. During extended chronic exposures of fish to selected toxicants, certain developmental stages have frequently shown a greater sensitivity than others. In 56 life-cycle toxicity tests completed during the last decade with 34 organic and inorganic chemicals and four species of fish, the embryo-larval and early juvenile life stages were the most, or among the most, sensitive. Tests with these stages can be used to estimate the maximum acceptable toxicant concentration (MATC) within a factor of two in most cases. Therefore, toxicity tests with these early life stages of fish should be useful in establishing water-quality criteria and in screening large numbers of chemicals.

SOURCE: ERL-D Library

Mount, D.I. 1977. Present approaches to toxicity testing -- A perspective. In: Aquatic Toxicology and Hazard Evaluation, ASTM STP 634. (F.L. Mayer and J.L. Hamelink, eds.). American Society for Testing and Materials. pp 5-14. (ERL-D Reprint #169)

Interest in aquatic toxicity tests is increasing as more emphasis is placed on control of highly toxic pollutants. While this interest offers an opportunity to increase the use of aquatic toxicity tests, there is a responsibility to recognize their limitations. Aquatic toxicology may well be developed into a recognized professional field along with medicine, pharmacology and others.

SOURCE: ERL-D Library

Paul, John F., and Richard L. Patterson. 1977. Hydrodynamic simulation of movement of larval fishes in Western Lake Erie and their vulnerability to power plant entrainment. pp 305-316. In: Proceedings of the 1977 Winter Simulation Conference (Harold J. Highland, Robert G. Sargent, J. William Schmidt, eds.), December 5-7, 1977, National Bureau of Standards. Winter Simulation Conference Board of Directors.

A three-dimensional, time-dependent transport model for yellow perch larvae in western Lake Erie was developed. The model was used to predict the vulnerability of larvae spawned in different sections of Michigan waters to entrainment by the Detroit Edison electrical generating plant at Monroe MI. Independent estimates of larval entrainment for 1975 and 1976 from Michigan waters were compared with the predicted results.

SOURCE: ERL-D Library

Pickering, Q., W. Brungs, and Marion Gast. 1977. Effects of exposure time and copper concentration on reproduction of the fathead minnow (Pimephales promelas). Water Res. 11:1079-1083. (ERL-D Reprint #180)

Three concurrent studies were conducted to determine the chronic effect of prespawning exposure to various concentrations of copper on fathead minnow reproduction. Copper was introduced into the three exposure systems to give 6-, 3-, and 0-months exposure prior to spawning. Prespawning exposure time had no significant effect on reproduction. Number of eggs produced per female decreased, however, with increase in copper concentrations. Egg production at copper concentrations of 37 $\mu g/l^{-1}$ and higher was significantly lower ($p=0.05$) than in the control, but at concentrations of 24 $\mu g\ l^{-1}$ and lower it was not different. The maximum acceptable toxicant concentration (MATC) was estimated to be 32 $\mu g$ Cu $l^{-1}$, which is 0.07 of the 96 hr LC50. This application factor for copper is similar to those found in other studies.

SOURCE: ERL-D Library

Poldoski, J.E. 1977. Computer-assisted furnace atomic absorption spectrometric analysis. Anal. Chem. 49:891-893. (ERL-D Reprint #156)

The use of furnace atomic absorption instrumentation with a turnkey chromatography data system is described. A simple addition of relays to the furnace power supply allows for automatic start-up of A/D conversion and spectrophotometer zeroing at the proper time. Manipulations involving editing, sorting and averaging of up to 250 atomization signals in an analysis run were accomplished by developing a procedure employing BASIC language programing techniques. The same dedicated data system was employed for all steps and post-run data processing, conveniently accomplished in 5-15 minutes, gave a tabulation of sample name, mean concentration, standard deviation, number of analyses, and percent recovery.

SOURCE: ERL-D Library

Poldoski, J.E. 1977. Molecular spectral interference in the determination of arsenic by furnace atomic absorption. Atomic Absorption Newsletter. 16(3):70-73. (ERL-D Reprint #161).

A molecular spectral interference associated with a certain type of suspended particulate matter in natural waters is reported for the furnace atomic absorption determination of arsenic. In some water samples, arsenic concentrations were erroneously high by more than a factor of five above the actual concentration. Results of analyses were confirmed by an alternate method. The degree of interference is a function of spectral bandpass and the concentration of hydrofluoric acid added to the sample. Use of 0.2 nm bandpass or 1% hydrofluoric acid markedly reduced the interference for the natural water samples investigated.

SOURCE: ERL-D Library

Poldoski, J.F., and G.E. Glass. 1977. Considerations of trace element chemistry for streams in the Minnesota-Ontario border area. In: Proceedings of the International Conference on Heavy Metals in the Environment, T.C. Hutchinson et al., editors, Vol. II, Toronto, Ontario, Canada, pp 901-922. (ERL-D Reprint #176)

Mean total concentrations (µg/l, unfiltered) of copper, nickel, cadmium, lead and zinc in streams of Superior National Forest were found to be 1.8 ± 1.5, <2, 0.026 ± 0.016, 0.38 ± 0.21 and 2.0 ± 0.8, respectively, during a year's period (1974-75). Furnace atomic absorption spectroscopy was found to provide sufficient sensitivity and precision for the determination of these low baseline concentrations. Comparisons of river water analyses by the furnace technique to analyses by anodic film stripping voltammetry for copper, cadmium and lead and by flame atomic absorption for nickel showed good agreement. Potentiometric ion selective electrode measurements for "free" cadmium added to naturally colored river water indicated less than 30 percent binding for concentrations in the 10-100 µg/l range.

SOURCE: ERL-D Library

Siefert, Richard E., and Lawrence J. Herman. 1977. Spawning success of the black crappie, Pomoxis nigromaculatus, at reduced dissolved oxygen concentrations. Trans. Am. Fish. Soc. 106(4):376-379. (ERL-D Reprint #170)

Mature black crappies (Pomoxis nigromaculatus) were exposed to constant dissolved oxygen (DO) concentrations near or at 2.5, 3.5, 5.0, or 6.5 mg/l, and near air saturation (control) to determine the effects of reduced DO on spawning success. The fish spawned successfully 39 times in laboratory tanks under a simulated natural temperature and light regime at all DO concentrations tested. Fish at 2.5 mg/l DO started and finished spawning at earlier dates than those at the higher oxygen concentrations; fish at saturation started and finished spawning at

later dates than those at the reduced concentrations. The number of embryos from a single spawning ranged from 14,600 to 155,300. Number of spawnings, viability of embryos, hatching success, and survival through swim-up were similar between control fish and those exposed to reduced oxygen concentrations.

SOURCE: ERL-D Library

Spoor, W.A. 1977. Oxygen requirements of embryos and larvae of the large-mouth bass, Micropterus salmonides (Lacepede). J. Fish Biology. 11:77-86. (ERL-D Reprint #171).

Starting with the second day after fertilization, largemouth bass embryos and larvae became increasingly sensitive to oxygen deficiency until the sixth day of life. On this day few survived exposure to 1 mg $O_2$/l for 3 hr at 20°C; many were damaged at 2 mg/l, but not at 2.5. Death was by asphyxiation or by starvation resulting from an apparent inability to close the lower jaw. On the seventh day the larvae became more resistant again, possibly because opercular movement began on that day. At 25°C the effects of reduced oxygen concentration were intensified, and even a concentration of 2.5 mg/l became lethal in 3 hr. At 3 mg $O_2$/l and 20° the normally quiescent yolk-sac larvae became very active and swam vertically to at least 5 or 6 cm above the substrate; 4 and 5 mg/l and this effect at 23-24°C. This behavior could result in losses by predation and displacement from the nest.

SOURCE: ERL-D Library

Stephan, Charles E. 1977. Methods for calculating an LC50. In: Aquatic Toxicology and Hazard Evaluation, ASTM STP 634. (F.L. Mayer and J.L. Hamelink eds.). American Society for Testing and Materials. pp 65-84. (ERL-D Reprint #168)

A variety of graphical and computational methods can be used to derive a median lethal concentration (LC50) from concentration-mortality data produced by an acute mortality test. In the selection of a method, practical considerations should receive as much attention as the usual theoretical and statistical considerations. No method should be used that does not calculate both the LC50 and its 95 percent confidence limits. Unfortunately, several computational methods will not calculate an LC50 from some concentration-mortality data that are practically and statistically useful to aquatic toxicologists. Useful, statistically sound information about the LC50 and its 95 percent confidence limits can be calculated from the data produced by any acute mortality test that meets published criteria of acceptability, by using an internally consistent scheme based on the moving average method and the binomial test.

SOURCE: ERL-D Library

Veith, G.D. and L.M. Kiwus. 1977. An exhaustive steam-distillation and solvent-extraction unit for pesticides and industrial chemicals. Bull. Environ. Contam. Toxicol. 17(6):631-636. (ERL-D Reprint #162)

We have developed a modified Nielsen-Kryger steam-distillation apparatus that provides exhaustive distillation of pesticides and industrial chemicals from water, sediments, and tissue and the simultaneous extraction of the distillate by a small volume of organic solvent. The extract is generally suitable for direct gas-liquid chromatography (GLC) analysis without the time-consuming concentration and cleanup procedures.

SOURCE: ERL-D Library

Veith, G.D., D.W. Kuehl, F.A. Puglisi, G.E. Glass, and J.G. Eaton. 1977. Residues of PCB's and DDT in the western Lake Superior ecosystem. Arch. Environ. Contam. Toxicol. 5:487-499. (ERL-D Reprint #165)

Fish from western Lake Superior (1972-73) contained DDT and PCB residues at concentrations greater than 0.1 ppm. The most perdominant PCBs were those containing 3 to 6 chlorine atoms per molecule, and GLC data indicated that the mixtures were most like the commercial product Aroclor$^{R}$ 1254$^{2}$. Other chlorinated contaminants identified by GC/MS analyses and occurring at concentrations less than 0.1 ppm were hexachlorobenzene ($C_6Cl_6$), chlordane, nonaclor, and dieldrin. Lindane which has been previously reported in Lake Superior, was below the detection limit of approximately 0.01 ppm.

The relationship between the size of lake trout and the concentration of total DDT in the fish was compared to measurements reported in previous studies. The comparison suggests that DDT residues have declined since 1968. The concentration of PCBs was estimated to be 0.8 ng/l in Lake Superior water and 0.1 ppm in large zooplankton. The apparent bioconcentration factor for PCBs in Lake Superior fish ranged from $10^5$ to $10^6$. The concentration of total DDT and PCBs in the larger Lake Superior fish exceeded the 5 ppm tolerance level established by the U.S. Food and Drug Administration for these in fish to be used for human consumption.

SOURCE: ERL-D Library

# 1976

Andrew, R.W. 1976. Toxicity relationships to copper forms in natural waters. In: Toxicity to biota of metal forms in natural water, Proceedings of a Workshop Held in Duluth, MN, October 7-8, 1975. (Andrew, R.W., P.V. Hodson, and D.E. Konasewich, eds.). International Joint Commission, Windsor, Ontario. pp. 127-144.

For several years ERL-D has studied the acute toxicity of cupric salts to aquatic organisms, principally fathead minnows and Daphnia magna, as a function of water chemistry. In general copper complexes, e.g. soluble $CuCO_3$ or Cu NTA$^-$ proved much less toxic than cupric ion ($Cu^{++}$). Similarly, copper precipitates are not biologically active and do not result in toxicity. Recent work correlates well with cupric ion activities measured using an ion specific electrode, indicating cupric-ion ($Cu^{++}$) as the major toxic form of copper. This suggests that increased cupric ion toxicity at high pH may result from interactions with sulfhydryl-containing proteins or enzymes.

SOURCE: ERL-D Library

Nalepa, T.F. and N.A. Thomas. 1976. Distribution of macrobenthic species in Lake Ontario in relation to sources of pollution and sediment parameters. J. Great Lakes Res. 2(1):150-163.

Bottom samples were collected in Lake Ontario during the International Field Year for the Great Lakes (IFYGL) in November 1972. Samples were collected in triplicate at 55 stations located throughout the lake. Sand prevailed at the shallow areas but silt dominated the intermediate and deep-water areas. Total carbon and total Kjeldahl nitrogen content of the sediment increased with increased depth, but no trend was evident in the total phosphorus content. Oligochaetes and the amphipod Pontoporeia affinis accounted for 92% of all organisms collected. The former group dominated the shallow areas while the latter dominated the intermediate and deep-water zones. Stylodrilus heringianus and Linmodrilus hoffmeisteri were the most widely distributed species, being collected at 51 of the 55 stations. Several approaches were used to evaluate trophic conditions in the lake---the indicator species approach, the oligochaete-density index, a modified "Goodnight-Whitley" index, and the Brinkhurst % L. hoffmeisteri index. The indicator species approach proved to be the most sensitive index because inconsistencies arose when the other indices were applied. The most obviously eutrophic areas were near the mouth of the Niagara River and off Toronto. These areas were characterized by high oligochaete densities dominated by either L. hoffmeisteri or T. tubifex. Mesotrophic conditions were evident along the southern shoreline from the mouth of the Niagara River to Rochester, NY. Stylodrilus heringianus, L. hoffmeisteri, T. tubifex and P. affinis were significantly related to some of the measured sediment parameters in either the intermediate or deep-water areas.

SOURCE: LLRS

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